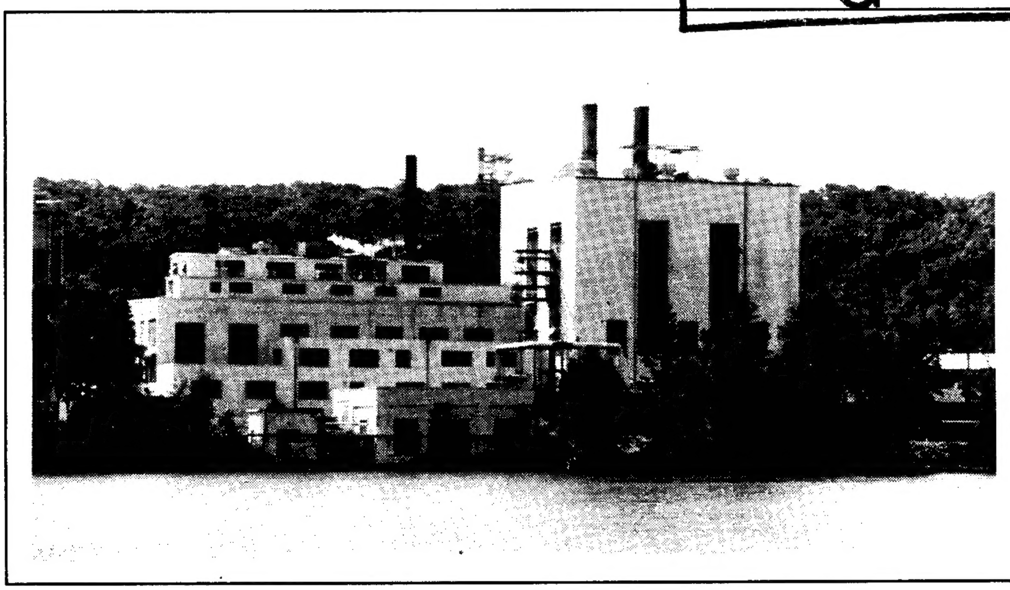
US Army Corps
of Engineers
Construction Engineering
Research Laboratories

USACERL Technical Report FE-95/13
March 1995

The Central Heating Plant Status Quo Program

by
Martin J. Savoie
Ronald D. Tarvin
Travis L. McCammon
Richard E. Carroll
D. Al Wicks
Ralph E. Moshage



The Fiscal Year 1986 Defense Appropriation Act (PL-99-190), Section 8110, directed the Department of Defense (DOD) to rehabilitate and convert central energy plants to coal firing where a cost benefit could be realized. To satisfy this requirement, the life cycle costs of potential fuel/technology alternatives must be compared.

The Status Quo program is one component of a series of programs being developed by the U.S. Army Construction Engineering Research Laboratories to evaluate coal conversion alternatives. Status Quo is a microcomputer program that estimates the life cycle costs of maintaining an existing energy plant in its present condition, thereby providing a baseline for comparing the life cycle costs of alternatives to the status quo: modernization, retrofit, or construction of a new plant.

This program works in conjunction with (and requires) the Life Cycle Cost in Design (LCCID) computer program, and is designed to run on any IBM personal computer or compatible with at least 640K of random access memory and about 1.4 megabytes of free hard drive space.

ERRATA

Note that the report number has been changed to:

USACERL Technical Report FE-95/13.

The correct number is reflected on the Cover, User Evaluation of Report, and Report Documentation Page.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave Blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 1995	Final

4. TITLE AND SUBTITLE
The Central Heating Plant Status Quo Program

5. FUNDING NUMBERS
MIPR
W56HZV-89-AC-01

6. AUTHOR(S)
Martin J. Savoie, Ronald D. Tarvin, Travis L. McCammon, Richard E. Carroll, D. Al Wicks, and Ralph E. Moshage

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Construction Engineering Research Laboratories (USACERL)
P.O. Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
FE-95/13

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Center for Public Works (USACPW)
ATTN: CECPW-FU-P
7701 Telegraph Road
Alexandria, VA 22310-3862

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Fiscal Year 1986 Defense Appropriation Act (PL-99-190), Section 8110, directed the Department of Defense (DOD) to rehabilitate and convert central energy plants to coal firing where a cost benefit could be realized. To satisfy this requirement, the life cycle costs of potential fuel/technology alternatives must be compared.

The Status Quo program is one component of a series of programs being developed by the U.S. Army Construction Engineering Research Laboratories to evaluate coal conversion alternatives. Status Quo is a microcomputer program that estimates the life cycle costs of maintaining an existing energy plant in its present condition, thereby providing a baseline for comparing the life cycle costs of alternatives to the status quo: modernization, retrofit, or construction of a new plant.

This program works in conjunction with (and requires) the Life Cycle Cost in Design (LCCID) computer program, and is designed to run on any IBM personal computer or compatible with at least 640K of random access memory and about 1.4 megabytes of free hard drive space.

14. SUBJECT TERMS
life cycle cost in design (LCCID)
central heating plants
coal conversion
life cycle costs
status quo

15. NUMBER OF PAGES
108

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

Foreword

This study was conducted for U.S. Army Center for Public Works (USACPW) under Military Interdepartmental Purchase Request (MIPR) No. W56HZV-89-AC-01; Work Unit WP0, "Coal Conversion Strategies for DOD." The technical monitor was James Donnelly, CECPW-FU-P.

The work was performed by the Energy and Utility Systems Division (FE) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Martin J. Savoie and Ralph E. Moshage were the principal investigators. Richard E. Carroll and D. Al Wicks are members of the mechanical design staff at Stanley Consultants, Inc., Muscatine, IA. Dr. David M. Joncich is Chief, CECER-FE, and Alan Moore is Acting Chief, CECER-FL. The USACERL technical editor was Gloria J. Wienke, Information Management Office.

LTC David J. Rehbein is Commander and Acting Director of USACERL, and Dr. Michael J. O'Connor is Technical Director.

Contents

SF 298 1

Foreword 2

1 Introduction 5
Background 5
Objective 6
Approach 6
Scope 10
Mode of Technology Transfer 10

2 Status Quo 11
Test Run for Fort Campbell 13
Test Run for Rock Island Arsenal 13

3 Conclusions and Recommendations 21

Appendix A: System and Equipment Descriptions 23

Appendix B: Database File Structures 50

Appendix C: Data for DEFAULT.DBF 51

Appendix D: Data in VALID.DBF 72

Appendix E: Data Collection Forms for Oil and Gas 81

Appendix F: Data Collection Forms for Coal 87

Appendix G: Status Quo Program User's Manual 94

Distribution

1 Introduction

Background

The Fiscal Year 1986 (FY86) Defense Appropriation Act (PL-99-190), Section 8110, directed the Department of Defense (DOD) to rehabilitate and convert central energy plants (CEPs) to coal firing if a cost benefit could be realized. Section 8110 formed the basis for the Army's Coal Conversion Program and set a target level of coal consumption, to be achieved by 1994, of 1.6 million short tons per year more than the 1985 DOD coal consumption level for the continental United States (1.3 million tons).* The law further stipulates that 300,000 tons of the coal burned should be anthracite coal. (This condition was intended to offset the decreasing use of anthracite coal in Germany resulting from the connection of U.S. Army Europe [USAREUR] installations to district heating systems.) To help the DOD comply with this law, the U.S. Army Center for Public Works (USACPW) requested the U.S. Army Construction Engineering Research Laboratories (USACERL) to provide technical studies and support for the Army's Coal Conversion Program.

To satisfy the Section 8110 directive, the DOD must select fuel/technology alternatives that will operate most economically through the life cycle of its heating plants. The DOD already uses the Life Cycle Cost in Design (LCCID) economic analysis computer program to evaluate and rank design alternatives for new facilities.** LCCID calculates the present-worth life-cycle cost, payback period, and savings-investment ratio for Army facilities. LCCID also compares and ranks energy supply alternatives according to these cost methods, providing a consistent method to evaluate central heating system energy supply alternatives.

This study developed "Status Quo," a computer program that uses data from an existing central heating plant, evaluates the plant's condition, and estimates its life-cycle cost. The output of the Status Quo program is an LCCID input file containing information on all plant components, including their replacement year and cost, and

---

* 1 ton = 907.185 kg.

** For more information on LCCID, refer to: L.K. Lawrie, *Development and Use of the Life Cycle Cost in Design Computer Program (LCCID)*, Technical Report (TR) E-85/07/ADA162522 (U.S. Army Construction Engineering Research Laboratories [USACERL], November 1985).

the costs of plant labor, maintenance, spare parts, and utilities. This information forms the baseline for comparing different fuel/technology alternatives, and can be integrated with other coal conversion analysis procedures that have already been tested.

The Status Quo program is designed to run on an IBM personal computer (PC) or compatible computer with 640K of random access memory (RAM), and about 1.4 megabytes of free hard drive space.

Objective

The objective of this research effort was to develop an automated procedure to evaluate the condition and estimate the life-cycle costs of an existing coal-fired or oil/gas-fired central heating plant, to provide a baseline or "status quo" alternative to compare with modernization, retrofit, and new plant construction alternatives.

Approach

Development of the Status Quo program was divided into two phases: the investigation of oil- and natural gas-fired combustion technologies, and the investigation of coal-fired technologies. Oil technologies were investigated first because those systems are less complex than coal technologoies. The first step in developing the Status Quo program for heating plants was to identify major capital equipment components and systems typical of Army plants, which range from 20 to 200 MBtu/hr per boiler for oil- and natural gas-fired heating plants, up to 600 MBtu/hr total plant capacity (1 Btu/hr = 0.2931 W). Table 1 lists the principal systems considered in this study. Appendix A contains a complete description of the systems and components.

The next step was to determine replacement cost factors for each component or system. These factors were developed from recent industrial heating plant replacement projects and Army Corps of Engineers cost guidelines.

Next, the remaining useful life was estimated based on industry experience. A procedure was also developed to determine the expected operation and maintenance G(O&M) costs for a central heating plant, also based on typical operating conditions.

Table 1. Central heating plant components

Boilers	
Oil or natural gas	Drum level control
Boiler information	Underfeed stoker
Relief valves	Overfeed stoker
Feedwater regulators	Spreader stoker
Burners	Stoker variations • chain grate • traveling grate • fixed/dump grate
Forced draft fans	Overfire air systems
Induced draft fans	Ash reinjection systems
Economizer	Sootblowers
Air heater	Isolation dampers
Air preheater	Expansion joints
Feedwater System	
Deaerating heaters	Make-up pumps
Feedwater heaters	Boiler circulation water pumps
Treated water storage	Sediment tanks
Treated water pumps	Expansion tanks
Condensate pumps	Feedwater piping system
Condensate receivers	Cooling water pumps
Boiler feed pumps	HTW distribution system pumps
Fuel Handling System	
Unloading pumps	Heaters
Tanks - aboveground	Oil piping system
Tanks - underground	Natural gas piping system
Pumps	
Heat Recovery System	
Blowdown flash tanks	Blowdown heat exchangers

Air Pollution Control	
Mechanical collectors	Opacity monitors
Baghouses	Sulfur dioxide scrubbers
ESPs	Ash conveyors
Breechings	Ash storage
Stacks	
Combustion Controls	
Plant master controllers	Pressure controllers
Boiler controllers	Damper actuators
Oxygen trim systems	Flow meters
Flame safeguard systems	Temperature recorders
Pressure sensors	
Chemical Feed System	
Chemical feed tanks	Chemical feed pumps
Make-up Water System	
Chlorinators	Sodium zeolite softeners
Flocc./settling basins	Dealkalizers
Clarifiers	Zeolite split stream
Gravity filters	Reverse osmosis units
Pressure filters	Forced draft degasifiers
Carbon filters	Vacuum degasifiers
Sludge contact softeners	Demineralizers
Hot process softeners	Evaporators
Condensate Polishing	
Oil removal	Sodium cycle polishers
Diatomaceous filters	
Compressed Air System	
Air compressors	Air receivers
Air dryers	
Electrical System	
Transformers	Breakers
Switchgear/breakers	Starters
Motor control center	Emergency generators

Physical Plant	
Concrete	Windows
Steel	Doors
Roofing	Sump pumps
Siding	Lighting
Coal Handling Systems	
Air cannon	Spouts and chutes
Belt tripper	Bucket elevators
Screw conveyors	Rail hoppers
Belt conveyors	Magnetic separators
En masse conveyors	Carhoe
Dense phase transport	Car pullers
Mechanical feeders	Frozen coal crushers
Belt feeders	Belt coal scales
Coal distributors	Metal detectors
Storage systems	Metering bins
Piping and valves	
Fire Protection	
Water systems • wet • dry	CO_2 systems
Detection devices	

O&M costs were divided into categories for labor, spare parts and consumables, services, utilities, and fuel.

The information on central heating plant status quo was developed into a menu-driven microcomputer program that allows the user to enter plant information. This program was tested at several installations; data from Fort Campbell, KY, and Rock Island Arsenal, IL, are presented as examples of an oil- and natural gas-fired plant and a coal-fired plant, respectively.

Scope

The primary purpose of this work is to investigate the feasibility of converting Army central heating plants to coal firing. However, the Status Quo program may also be applied at the installation level to evaluate energy supply alternatives for industrial-size facilities that burn natural gas, oil, or coal. The program may also help establish a phased O&M plan and annual O&M budgets.

Note that the Status Quo program was designed to provide only an estimate of the equipment condition; detailed evaluation procedures considering maintenance and operating history were not developed. There are, however, techniques available to more closely determine life expectancy for many components, such as vibration analysis, thermography, and ultrasonic metal thickness detection.

Mode of Technology Transfer

It is anticipated that the algorithms developed in this study will be used in a microcomputer program that will eventually be incorporated into an existing cost-estimating program—LCCID, or Central Heating Plant Economics (CHPECON). LCCID is distributed and supported through the Blast Support Office (BSO), 30 Mechanical Engineering Bldg., 1206 W. Green Street, Urbana, IL 61801. CHPECON is another computer program currently being developed by USACERL under the Army's Coal Conversion Program. Support and distribution channels for CHPECON will be determined as the software is completed.

2 Status Quo

The Status Quo program is part of an overall strategy to determine the most cost effective alternative for meeting an installation's thermal and electrical energy requirements throughout the life cycle of its energy plants. To make that determination, many possible energy supply alternatives must be compared to the installation's current energy supply method (the status quo) to determine the best alternative. Also, the status quo must be established to evaluate other modernization opportunities such as retrofit with high-efficiency burners or cogeneration equipment, which can improve the plant operating condition and life-cycle cost without major construction.

Currently, the Status Quo program can estimate the life expectancy and life-cycle cost of oil- and natural gas-fired equipment for boilers in the 20 to 200 MBtu/hr range and for coal-fired boilers in the 25 to 250 MBtu/hr range, with a maximum plant capacity of 600 MBtu/hr. The program data input is quite simple, consisting primarily of the size and year of installation for major CEP components. Component size may be defined by physical dimensions, capacity, power requirement, or some other measure the program needs to determine component cost. The year of installation is needed to calculate the remaining life of the component. Appendixes B, C, and D show the data structure, default values, and component size parameters for the Status Quo database. Appendixes E and F contain the forms for data collection for oil/gas and coal, respectively.

Once the data is entered, the program will display, for each component, the equipment cost in base year dollars (1991 or 1992) and the year the equipment should be replaced. Costs are based on average industry prices and the replacement year is based on industry experience.* Program default values may be changed when newer information becomes available.

For example, a good way to establish water tube boiler life is to measure the steam drum thickness and compare it to the original thickness and pressure rating. Boiler codes limit allowable pressures based on drum thickness, so the current pressure rating and the installed design pressure can be plotted against time. The remaining

* This information was compiled for USACERL by Stanley Consultants, Stanley Building, Muscatine, IA 52761.

life is estimated by the intersection of the allowable pressure and the operating pressure required to supply steam to the users (Figure 1). Other components may require different methods to determine their condition and life expectancy, including: vibration analysis, motor testing, ultrasonic listening, thickness testing, oil analysis or ferrography, infrared thermal surveys, eddy current testing, equipment performance tracking, equipment run time, and age.

After component data is entered, the user enters annual costs for labor, maintenance, spare parts, and utilities. The program contains default values, but actual costs should be used whenever possible for a more accurate economic analysis. Appendix G contains a draft user's manual, which details the data input for the Status Quo program.

The Status Quo program uses LCCID to perform the life cycle cost analysis. The LCCID program is an economic analysis computer program designed to evaluate and rank design alternatives for new and existing DOD facilities. LCCID incorporates Army, Navy, and Air Force economic criteria for design studies, and operates in a manner that does not require the user to know this criteria. LCCID provides the present worth life cycle cost, payback period, and savings-to-investment ratio. Each energy supply alternative can be compared and ranked according to each of these cost methods, thereby providing a consistent method to evaluate any central heating system energy supply alternative.

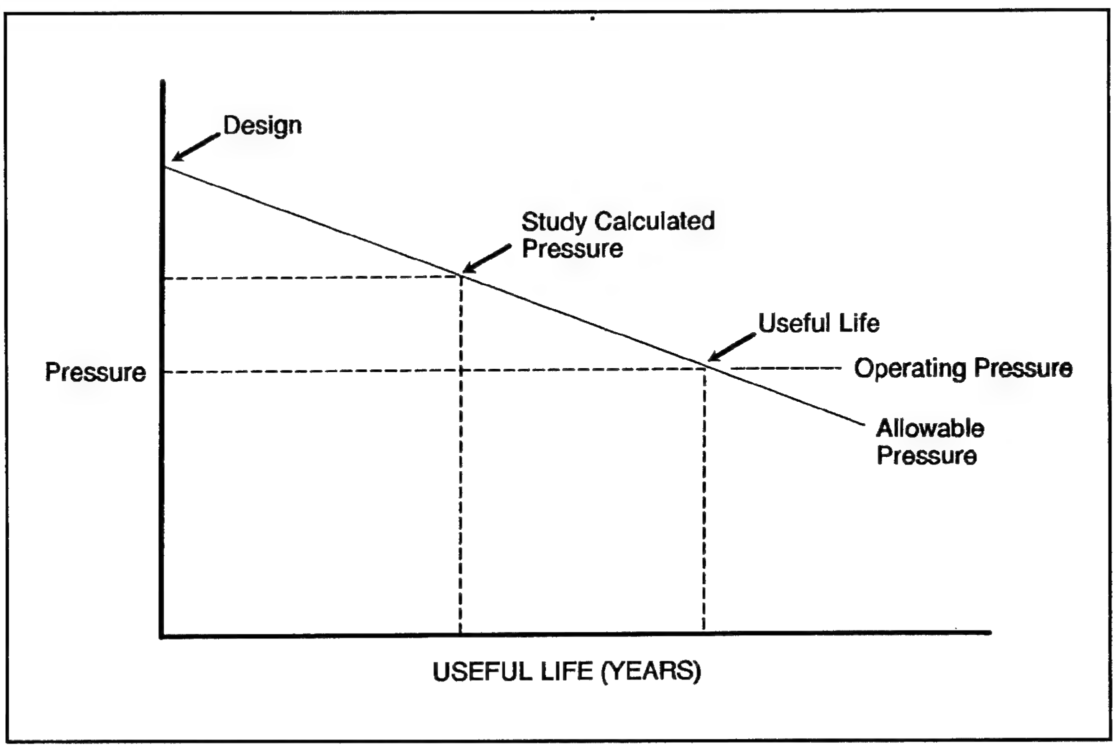


Figure 1. Steam drum useful life chart.

The Status Quo program produces an LCCID input file containing all the plant components with their replacement year and cost, and the plant labor, maintenance, spare parts, and utility costs. The program then runs the LCCID program automatically. All data is saved in a user-defined file that can be modified later, if required.

Test Run for Fort Campbell

The Status Quo program was tested in 1992 at Fort Campbell, KY, Fort Gordon, GA, Fort Bragg, NC, and Picatinny Arsenal, NJ, to identify any system or technical problems. At Fort Campbell, the central plant at Building 650 supplies steam to the hospital, which was completed in 1982. The plant contains three 15,000 lb/hr steam boilers that were installed in 1978 (1 lb/hr = 1000 Btu/hr). In 1990, the boilers were converted from burning No. 5 oil to natural gas, with No. 2 oil used as the reserve fuel. The boilers underwent a major overhaul in 1990 to repair damage that occurred while burning No. 5 oil. In addition to providing steam for heating, the steam from the plant also supplies a 640 ton/hr steam absorption chiller that provides part of the hospital's cooling.

The data needed for the Status Quo program was obtained by a site survey and entered into the program. Table 2 lists the basic input data summary from the LCCID portion of the program. The first column lists the expenditure type, the second column lists the cost, the third column lists the escalation rate (used only for energy costs), and the last column shows the dates when the cost is scheduled. No initial investments were required in the first year of the study. The study used a discount factor of 4.6 percent and a project life of 25 years, starting January 1994. This discount rate is required by the Army for Fiscal Year 1992 (FY92) energy projects, and is taken from: *Energy Prices and Discount Factors for the Life-Cycle Cost Analysis*, NISTIR 85-3273 (National Institute of Standards and Technology [NIST], updated annually).

Table 3 shows the net present worth (PW) of the life cycle cost of the Status Quo program. Table 4 shows a year-by-year expenditure profile for fuel, recurring maintenance and repair, and major repair and replacement costs. The expenditure profile will provide installation engineers with a good way to estimate O&M requirements and costs for planning the installation's O&M budget.

Test Run for Rock Island Arsenal

At Rock Island Arsenal, IL, the central heating plant at Building 227 contains three 125,000 lb/hr steam boilers installed in 1941, 1942, and 1963 and one 75,000 lb/hr

Table 2. Basic input summary for Fort Campbell.

Cost/Benefit Description	Costs in Date of Study $ ($ X 10**0)	Equivalent Uniform Differential Escalation Rate (% Per Year)	Time(s) Cost Incurred
INVESTMENT COSTS	0.0	0.00	JAN 94
DISTILLATE OIL	60600.0	1.58	JUL95-JUL19
RESIDUAL OIL	8396.9	2.11	JUL95-JUL19
NATURAL GAS	729332.8	3.64	JUL95-JUL19
MAINT LABOR	122500.0	0.00	JUL95-JUL19
MAINT SERV	12162.0	0.00	JUL95-JUL19
MAINT SUPPLY	90000.0	0.00	JUL95-JUL19
MAINT UTIL	60811.0	0.00	JUL95-JUL19
STACK	18000.0	0.00	JAN 18
DRUMCTL	15000.0	0.00	JAN 98
ECONOMIZER	105000.0	0.00	JAN 98
F FAN	21000.0	0.00	JAN 18
RELVALVE	6800.0	0.00	JAN 98
RELVALVE	3400.0	0.00	JAN 11
WTBURNER	150000.0	0.00	JAN 18
PUMPSIMPLEX	3000.0	0.00	JAN 98
TANKPOLY	200.0	0.00	JAN 98
BOILMASTER	15000.0	0.00	JAN 08
DAMPACT	3000.0	0.00	JAN 08
FLAMESAFE	30000.0	0.00	JAN 08
PLANTMASTER	5000.0	0.00	JAN 08
AIRCOMPRECIP	20000.0	0.00	JAN 98
AIRDRYERREFR	12000.0	0.00	JAN 93
EMERGENCYGEN	276000.0	0.00	JAN 08
SWITCH	20000.0	0.00	JAN 18
CONDPUMP	8000.0	0.00	JAN 98
CONDREC	22000.0	0.00	JAN 08
FEEDPUMP	45750.0	0.00	JAN 08
NAGPIPEBELOW	13.0	0.00	JAN 15
OILPIPEBELOW	25.0	0.00	JAN 03
PUMP	3250.0	0.00	JAN 03
TANKBELOW	42000.0	0.00	JAN 08
SZSOFT	231000.0	0.00	JAN 12
SUMPPUMPVERT	5000.0	0.00	JAN 93

steam boiler installed in 1966. All four boilers are coal-fired with no auxiliary fuel. Rock Island Arsenal uses steam mostly for space heating; however, some process steam is used for plating tanks, running forge presses, and for cooking. The arsenal also uses approximately 1500 tons of absorption chilling.

The data needed for the Status Quo program was obtained during a site survey and entered into the program. Annual operation and maintenance costs and electrical use for the heating plant were estimated using the CHPECON Evaluation Program, developed by the Institute of Gas Technology. Table 5 lists the basic input data summary from the LCCID portion of the program. The first column lists the expenditure type, the second column lists the cost, the third column lists the escalation rate (used only for energy costs), and the last column shows the dates when the cost is scheduled. No initial investments were required in the first year of the study. The study used a discount factor of 4.0 percent and a project life of 25 years, starting January 1994. This discount rate is required by the Army for FY93 energy projects, and is taken from: *Energy Prices and Discount Factors for the Life-Cycle Cost Analysis*, NISTIR 85-3273 (NIST, updated annually).

Table 6 shows the net PW of the life cycle cost of the Status Quo program. Table 7 shows a year-by-year expenditure profile for fuel, recurring maintenance and repair, and major repair and replacement costs. The expenditure profile will provide installation engineers a good way to estimate O&M requirements and costs for planning the installation's O&M budget.

Table 3. Life cycle cost summary.

Factors		Costs ($)
Energy Costs:		
Distillate oil	984,832.00	
Residual oil	148,059.00	
Natural gas	15,506,270.00	
Total Energy Costs	16,639,160.00	16,369,160.00
Recurring M&R/custodial costs		3,786,598.00
Major repair/replacement costs		502,230.00
Other O&M costs & monetary benefits		0.00
Disposal costs/retention value		0.00
LCC of all costs/benefits (net present worth)		20,927,990.00

Table 4. Year-by-year breakdown of life cycle costs for Fort Campbell.

Pay	Dist	Resid	Nat G	M&R	R/R	Other
1	52,772.00	7,847.00	647,997.00	246,653.00	0.00	0.00
2	50,440.00	7,521.00	619,500.00	235,806.00	0.00	0.00
3	48,267.00	7,172.00	597,166.00	225,436.00	0.00	0.00
4	46,434.00	6,887.00	579,511.00	215,522.00	121,997.00	0.00
5	45,343.00	6,739.00	583,025.00	206,044.00	0.00	0.00
6	44,565.00	6,646.00	595,981.00	196,983.00	0.00	0.00
7	43,925.00	6,573.00	614,158.00	188,320.00	0.00	0.00
8	43,475.00	6,527.00	643,188.00	180,038.00	0.00	0.00
9	43,020.00	6,482.00	663,287.00	172,121.00	2,020.00	0.00
10	42,505.00	6,420.00	670,113.00	164,552.00	0.00	0.00
11	41,962.00	6,353.00	684,487.00	157,315.00	0.00	0.00
12	41,212.00	6,249.00	692,231.00	150,397.00	0.00	0.00
13	40,309.00	6,112.00	695,235.00	143,783.00	0.00	0.00
14	39,226.00	5,940.00	687,726.00	137,460.00	216,069.00	0.00
15	38,040.00	5,746.00	670,886.00	131,415.00	0.00	0.00
16	36,731.00	5,548.00	661,863.00	125,635.00	0.00	0.00
17	35,578.00	5,375.00	645,495.00	120,110.00	1,463.00	0.00
18	34,652.00	5,235.00	628,700.00	114,828.00	95,030.00	0.00
19	33,787.00	5,104.00	612,997.00	109,778.00	0.00	0.00
20	32,863.00	4,965.00	596,240.00	104,951.00	0.00	0.00
21	31,934.00	4,824.00	579,376.00	100,335.00	5.00	0.00
22	30,900.00	4,668.00	560,614.00	95,923.00	0.00	0.00
23	29,914.00	4,519.00	542,727.00	91,704.00	0.00	0.00
24	28,974.00	4,377.00	525,674.00	87,671.00	65,646.00	0.00
25	28,005.00	4,231.00	508,096.00	83,816.00	0.00	0.00
(Totals)	984,832.00	148,059.00	15,506,273.00	3,786,598.00	502,230.00	0.00

Table 5. Basic input summary for Rock Island Arsenal.

Cost/Benefit Description	Costs in Date of Study $ ($ X 10**0)	Equivalent Uniform Differential Escalation Rate (% Per Year)	Time(s) Cost Incurred
INVESTMENT COSTS	0.0	0.00	JAN 94
ELECTRICITY	190919.7	0.30	JUL95-JUL19
COAL	1659509.0	1.25	JUL95-JUL19
MAINT LABOR	607047.0	0.00	JUL95-JUL19
MAINT SERV	352034.0	0.00	JUL95-JUL19
MAINT SUPPLY	558505.0	0.00	JUL95-JUL19
MAINT UTIL	148389.0	0.00	JUL95-JUL19
ASHCONV	60500.0	0.00	JAN 17
COLLECTOR	40600.0	0.00	JAN 06
COLLECTOR	57800.0	0.00	JAN 93
COLLECTOR	57800.0	0.00	JAN 93
COLLECTOR	57800.0	0.00	JAN 03
CSTEEL STACK	84750.0	0.00	JAN 03
CSTEEL STACK	84750.0	0.00	JAN 06
OPACMONITOR	100000.0	0.00	JAN 18
COAL BOILER	1351593.0	0.00	JAN 06
COAL BOILER	1705493.0	0.00	JAN 93
COAL BOILER	1705493.0	0.00	JAN 93
COAL BOILER	1711993.0	0.00	JAN 03
DRUMCTL	5000.0	0.00	JAN 04
ECONOMIZER	87983.0	0.00	JAN 00
ECONOMIZER	357675.0	0.00	JAN 00
FLYASH-APIP	432.0	0.00	JAN 20
FLYASH-HEADR	542.0	0.00	JAN 20
FW REG	700.0	0.00	JAN 06
FW REG	800.0	0.00	JAN 03
FW REG	800.0	0.00	JAN 93
FW REG	800.0	0.00	JAN 93
F FAN	60000.0	0.00	JAN 03
I FAN	57500.0	0.00	JAN 93
I FAN	57500.0	0.00	JAN 93
I FAN	57500.0	0.00	JAN 06
I FAN	64000.0	0.00	JAN 03

Cost/Benefit Description	Costs in Date of Study $ ($ X 10**0)	Equivalent Uniform Differential Escalation Rate (% Per Year)	Time(s) Cost Incurred
OVRFIRE-DAMP	1395.0	0.00	JAN 03
OVRFIRE-DAMP	1395.0	0.00	JAN 06
OVRFIRE-FAN	53000.0	0.00	JAN 03
OVRFIRE-FAN	53000.0	0.00	JAN 06
OVRFIRE-PIPE	2080.0	0.00	JAN 03
OVRFIRE-PIPE	2080.0	0.00	JAN 06
RELVALVE	4707.0	0.00	JAN 13
RELVALVE	4707.0	0.00	JAN 13
RELVALVE	5859.0	0.00	JAN 13
RELVALVE	5859.0	0.00	JAN 13
PUMPSIMPLEX	9000.0	0.00	JAN 93
TANKSTEEL	1000.0	0.00	JAN 93
BINS	141000.0	0.00	JAN 93
BLTCONV TRUS	81950.0	0.00	JAN 17
BLT TRIPPER	33600.0	0.00	JAN 05
BUCKET ELEV	65050.0	0.00	JAN 03
CARHOE	38800.0	0.00	JAN 95
FRZN C CRSHR	30571.0	0.00	JAN 17
STRGE DRAIND	3.0	0.00	JAN 03
VOL VIB FDR	104889.0	0.00	JAN 07
RAIL HOPPER	40000.0	0.00	JAN 15
BOILMASTER	5000.0	0.00	JAN 19
DAMPACT	1100.0	0.00	JAN 19
FLOWMETER	3100.0	0.00	JAN 19
PLANTMASTER	5000.0	0.00	JAN 19
PSIGCTRL	2600.0	0.00	JAN 19
PSIGSENSOR	1100.0	0.00	JAN 19
TEMPREC	3100.0	0.00	JAN 19
AIRCOMPCENTR	20960.0	0.00	JAN 93
AIRCOMPCENTR	26000.0	0.00	JAN 93
AIRDRYERDESC	16880.0	0.00	JAN 03
AIRRECV	775.0	0.00	JAN 13
CONDPUMP	28000.0	0.00	JAN 13
CONDREC	141662.0	0.00	JAN 90

Cost/Benefit Description	Costs in Date of Study $ ($ X 10**0)	Equivalent Uniform Differential Escalation Rate (% Per Year)	Time(s) Cost Incurred
FWPIPINGVAL	5600.0	0.00	JAN 93
TREATPUMP	12500.0	0.00	JAN 08
HOTPROCSOFT	401667.0	0.00	JAN 96
SZSOFT	310000.0	0.00	JAN 12

Table 6. Life cycle cost summary for Rock Island Arsenal.

Factors		Costs ($)
Energy Costs:		
Electricity	2,916,754.00	
Coal	28,741,430.00	
Total Energy Costs	31,658,180.00	31,658,180.00
Recurring M&R/custodial costs		24,699,960.00
Major repair/replacement costs		3,532,658.00
Other O&M costs & monetary benefits		0.00
Disposal costs/retention value		0.00
LCC of all costs/benefits (net present worth)		59,890,800.00

Table 7. Year-by-year breakdown of life cycle costs for Rock Island Arsenal.

Pay	Elect	Coal	M&R	R/R	Other
1	173469.00	1551488.00	1520282.00	36108.00	0.00
2	167384.00	1508460.00	1461809.00	359422.00	0.00
3	158819.00	1448169.00	1405586.00	0.00	0.00
4	152457.00	1403451.00	1351525.00	0.00	0.00
5	147041.00	1360066.00	1299543.00	0.00	0.00
6	142697.00	1328060.00	1249561.00	340885.00	0.00
7	138289.00	1294603.00	1201501.00	0.00	0.00
8	133324.00	1259851.00	1155289.00	0.00	0.00
9	128938.00	1220450.00	1110855.00	1440059.00	0.00
10	125183.00	1190859.00	1068130.00	3269.00	0.00
11	121507.00	1165117.00	1027048.00	21124.00	0.00
12	117439.00	1144390.00	987546.00	962154.00	0.00
13	113303.00	1125108.00	949563.00	60968.00	0.00
14	109294.00	1110046.00	913042.00	6986.00	0.00
15	105275.00	1087406.00	877925.00	0.00	0.00
16	101887.00	1062066.00	844159.00	0.00	0.00
17	98620.00	1036715.00	811691.00	0.00	0.00
18	95408.00	1011797.00	780472.00	148104.00	0.00
19	92304.00	987474.00	750454.00	22926.00	0.00
20	89303.00	963736.00	721590.00	0.00	0.00
21	86402.00	940572.00	693837.00	16989.00	0.00
22	83599.00	917963.00	667151.00	0.00	0.00
23	80888.00	895893.00	641491.00	67942.00	0.00
24	78243.00	874357.00	616818.00	37758.00	0.00
25	75697.00	853341.00	593095.00	7624.00	0.00
(Totals)	2,916,754.00	28,741,438.00	24,699,963.00	3,532,658.00	0.00

3 Conclusions and Recommendations

The Status Quo program, which is one of the economic analysis tools under development for the Army Coal Conversion Program, can be used at most installations considering changes in their thermal or electrical supply. Status Quo will help develop annual O&M budgets and estimate the replacement cost of individual plant components such as feedwater pumps, deaerator systems, or air pollution control devices. This information will be helpful in evaluating third party financing and contract activity studies.

In addition to evaluating coal technology upgrades, the Status Quo program may also be used to help compare and evaluate centralized oil and natural gas energy supply alternatives.

The program could benefit from incorporating weighting factors such as reliability, hazardous materials, safety, and compliance with applicable codes and governmental regulations. Such weighting factors would be used to accelerate a component's replacement time.

Appendix A: System and Equipment Descriptions

Boiler (Fuel Firing Equipment)

For this study, boilers were categorized by the type of fuel used and by the boiler technology. Natural gas-/oil-fired boilers are categorized as fire tube or water tube and include package boilers and field-erected boilers. Coal-fired boilers are divided into the following categories:

- Spreader stokers
  - Traveling grate
  - Vibrating grate
  - Reciprocating grate
  - Stationary or dump grate

- Mass burn stokers
  - Water-cooled vibrating grate
  - Traveling grate

- Underfeed stokers
  - Single retort
  - Multiple retort

Spreader Stokers

A spreader stoker projects coal fuel into the furnace over the fire with a uniform spreading action, permitting burning of the fine fuel particles in suspension. The heavier pieces, which cannot be suspended in the gas flow, fall to the grate where they burn in a thin fast-burning bed.

A spreader stoker installation includes the following equipment: feeder-distributor units in widths and numbers as required to uniformly distribute the coal over the width of the grate; specially designed air-metering grates; forced-draft fans for both undergrate and overfire air; dust collection and reinjection equipment; and combustion controls to coordinate air and fuel supply with load demand. The fuel feeder-

distributor includes several components: a hopper, reciprocating feed plate, adjustable spill plate, a curved blade overthrow rotor and housing. This equipment provides a well-distributed, continuous supply of coal fuel at variable rates as required by the boiler.

Air-metering grates have been built in a variety of types and methods of operation. The first metering grates were stationary, requiring manual removal of ash through the front doors. The next development was the dumping grate. In this design, each feeder-distributor is provided with its own grate section and undergrate air plenum, which temporarily stops fuel and air supply to the grate section. This allows ash removal without affecting operation of other sections of the stoker.

Traveling grates, which provide for continuous ash discharge, were developed in the late 1930s. These grate designs provide a thin fast-burning fuel bed, allowing much higher capacities than stationary or dump grate designs. Other types of continuous ash discharge grate designs include vibrating and reciprocating grates. These designs, however, cannot achieve the high capacities of traveling grates and are limited to smaller units.

Mass Burn Stokers

Mass burn stokers slowly withdraw coal from a hopper, located at the front of the boiler, carry it the length of the boiler, and discharge ash at the rear of the boiler. Coal is burned continuously as it travels the length of the boiler.

The water-cooled vibrating grate stoker consists of a tuyere grate surface mounted on, and in contact with, a grid of water tubes interconnected with the boiler circulation system. The entire structure is supported on a number of flexing plates allowing the grid and its grate to freely vibrate. Operation of the grate is intermittent. Timing of the vibrations is regulated by the control system to conform to load requirements.

Underfeed Stokers

Underfeed stokers are generally of two types: (1) horizontal feed, side ash discharge or (2) gravity feed, rear ash discharge.

Horizontal feed, side ash discharge stokers can use either a single or double retort. Coal is fed from a hopper by means of a reciprocating ram or screw into a central trough called a retort. Screw feeders are used only on the very smallest boilers. A series of small auxiliary pushers in the bottom of the retort assist in moving the coal through the retort to the rear of the boiler. As the retort is filled, the coal fuel is moved

upward and spreads to each side of the air-admitting tuyeres and side grates. The double retort stoker design is similar, but uses two ram or screw feeders to feed coal to the two retorts.

Multiple retort, rear end cleaning stokers operate in a different fashion. The retort and grate is inclined at an angle of 20 to 25 degrees. Coal is fed from a hopper at the front of the boiler and moved the length of the boiler by a series of coal rams. An ash discharge plate restricts the coal flow at the rear of the boiler.

Overfire Air System

Overfire air systems are essential to successful suspension burning in all types of stoker-fired boilers. The system consists of a high-pressure fan (pressures of 27 to 30 inches, water gage are typical), piping, and dampers as required.

Customarily, at least two rows of evenly spaced, high-pressure air jets are installed in the furnace rear wall and one row in the front wall. The overfire air mixes with the furnace gases and creates necessary turbulence for complete combustion.

Flyash Reinjection Systems

The partial suspension burning, which occurs in spreader stoker-fired boilers, results in a greater carryover of particulate matter than with other types of stokers. This particulate matter contains a significant amount of unburned carbon, which can be recovered and reinjected into the boiler. Typical points in the system where this particulate matter may be recovered include the boilers last pass hopper, economizer hopper, and mechanical dust collector hopper. The flyash reinjection system consists of the following components: a high pressure fan and motor (frequently the overfire air system is used), dust piping, dust valves, and rotary feeders.

Fans and Drives

In addition to the overfire air and flyash reinjection system fans, two other major fan systems are used in stoker coal-fired central heating plants. These are the forced draft and induced draft fans. Forced draft fans provide the undergrate air supply for stoker-fired boilers. Typically, about 70 percent of the total air required for coal combustion is provided by the forced draft fan. The remaining 30 percent is supplied by the overfire and flyash reinjection system fans. Induced draft fans are installed between the boiler outlet and the inlet to the stack. Induced draft fans pull the products of combustion (flue gases) from the boiler and exhaust them to the stack.

Both forced and induced draft fans may be driven by electric motors connected directly to the fan shaft or v-belt drive or through a hydraulic fluid drive. An auxiliary steam turbine, complete with gear reducer and clutch may also be installed on these fans. Variable inlet dampers may be installed on these fans to assist in capacity control.

Isolation Dampers

Central heating plants containing multiple boilers require some means of isolating one or more boilers while the remainder of the plant is in service. Isolation dampers are one method of achieving this result. These dampers are installed in the boilers' exit ductwork and can be of several different types, including butterflies, multiple louvers, and guillotines.

Expansion Joints

Expansion joints are installed at various locations in a boiler's exhaust ductwork to allow the ductwork to expand and contract, without damage, as it is alternately heated or cooled due to operation of the boilers. Expansion joints must be capable of withstanding not only the temperatures normally experienced in the flue gas ductwork, but also occasional excursions of very high temperatures.

Sootblowers

All internal surfaces of a coal-fired boiler are subject to coating by deposits of ash and slag. These deposits reduce the transfer of heat from fuel combustion to the circulating water in the boiler and must be periodically removed. Furnace walls, the convection pass, and other surfaces are cleaned of ash and slag, while in operation, by the use of compressed air or steam sootblowers. Sootblowers may be retractable (motor operated) or nonretractable and consist of a long tube with multiple nozzles to direct the steam or compressed air against the surface to be cleaned as the sootblower is rotated. Sootblowers are arranged for automatic sequential cleaning and are operated by a dedicated control panel.

Air Heaters

Air heaters are installed in the flue gas ductwork between the furnace outlet and the stack on the flue gas side, and between the forced draft fan and the furnace on combustion air side, and can be of either the tubular type or regenerative type. These devices improve boiler efficiency by returning some of the heat energy contained in the flue gas to the furnace as heated combustion air. An air heater can improve boiler

efficiency by about 2.5 percent for each 100 degrees the flue gas temperature is decreased.

Economizers

Economizers are another type of heat recovery device that are installed in the flue gas ductwork between the furnace outlet and the fan or stack. Economizers use the heat energy of the flue gas to preheat the boiler feedwater, thus improving boiler efficiency. Virtually all modern economizers are designed with continuous tubes; each tube has several horizontal sections connected vertically by 180 degrees bends to permit draining. The preferred design is for gas from the boiler to flow down across the economizer tubes and for the water to enter at the bottom and flow up through the tubes. This counterflow design reduces to a minimum both the economizer's surface area and draft loss.

Feedwater System

The feedwater system will vary depending on the boiler size and pressure. A deaerator is installed to preheat the feedwater and remove the oxygen. The deaerator will be either the spray or tray type. The deaerating section may be separated from the storage section or it can be integral to the storage section. The storage section is usually sized to hold enough water to supply the boiler for 10 minutes at full load. A feedwater heater may be provided to heat the feedwater and make use of some waste heat.

A treated water storage tank may be provided along with pumps to move water from the tank to the deaerator. Condensate pumps will be provided to pump condensate from the condensate receiver to the deaerator. The condensate receiver will store condensate returns from the distribution system. The boiler feed pump will pump water from the deaerator to the boiler. Cooling water pumps may be provided to circulate cooling water to the various users.

Makeup water pumps will be provided for high temperature water (HTW) systems to pump water into the system. Boiler circulating pumps will provide continuous water circulation through the high temperature water generators and distribution pumps will supply HTW to the distribution system. A sediment tank will be provided on the HTW return system to settle out the larger particles of rust and scale from the piping.

Expansion tanks will be provided to accept the water from the system as it expands. The expansion tanks will be either steam or nitrogen pressurized.

Fuel Handling System

Fuel handling systems for gas/oil plants will generally consist of above-ground oil storage tanks, below-ground oil storage tanks, and/or a natural gas supply piping system.

Above-ground oil storage tank systems will normally have truck or rail car unloading stations to fill the tanks. The oil will be pumped from the truck or rail car to the tank by fuel oil unloading pumps. The tanks will be either horizontal or vertical and are usually constructed of steel. The tank roof on vertical tanks may be either fixed or floating.

The fuel oil tanks will be provided with a suction heater if the fuel is a heavy oil such as No. 6. The heater may also be used with lighter fuels in cold climates. The heater preheats the oil to reduce the viscosity so it can be pumped. The heater is usually designed to use steam, but may use high temperature water; some are electric heaters. The oil will move from the tanks to the fuel oil pumps that supply the burner.

Below-ground oil tanks will also be filled by unloading trucks or rail cars. Unloading pumps may not be required because often the oil flows by gravity to the tanks. Underground tanks may also be fitted with suction heaters to preheat the oil.

The fuel oil pumps that supply the burners will raise the oil pressure to about 100 psig (or the pressure required by the particular burner). Heavy oils will be heated to lower the viscosity before pumping to the burner and to allow for atomization in the burner. Heavy oil piping systems will have a supply and return pipe to and from the burner. This system will allow the continuous circulation of oil through the heater to keep the oil hot regardless of boiler load.

Natural gas systems will consist of a piping system that connects the gas transmission main to the central heating plant. The system will contain pressure reducing valves to provide a constant pressure gas supply to the burners.

Heat Recovery Systems

Heat recovery systems will usually consist of a blowdown tank and a blowdown heat exchanger. Blowdown from the boiler steam drum will go first to the blowdown tank where some of the water will flash to steam. This steam normally goes to a low pressure steam system. The remaining water will pass through the blowdown heat

exchanger to heat the feedwater on the way to the boiler. The blowdown heat exchanger can be either a shell and tube or a plate and frame design.

Makeup Water System

Boiler feedwater requires treatment to protect the boiler and the distribution system. Water treatment is needed to remove the impurities, such as chemical compounds, suspended solids, and dissolved gases, from boiler feedwater. Potable water is far too impure to use for feedwater. Uncontrolled concentrations of hardness components, suspended solids, alkalinity, oils, micro-organisms, and dissolved materials can cause major problems with boiler scale and corrosion.

Hardness components result from the presence of calcium and magnesium ions in the water. These ions combine with carbonate, bicarbonate, sulfate, nitrate, or chloride ions to form deposits.

Iron and other suspended solids are the largest cause of boiler deposit problems. The iron particles are caused by carbon dioxide and oxygen attacking the condensate system. Silica or silicon dioxide in boiler feedwater may precipitate to from a hard glassy material on boiler tube surfaces. In boilers operating above 400 psig, silica is carried with the steam to form deposits on piping and turbine blades.

Alkalinity is the result of carbonates, bicarbonates, hydroxide, and other negative ions in the feedwater. The alkalinity of the water determines the amount of acid the water can neutralize. Alkalinity must be maintained between limits. Alkalinity in feedwater stops corrosion from acids and promotes desired relationships between calcium and phosphate. If alkalinity is increased beyond its limit, corrosive attack and carryover can occur.

Chlorination

Most waters used for cooling purposes and some waters used for makeup purposes are infected with slime-forming micro-organisms. The multiplication of these micro-organisms is accelerated at warm water contact surfaces such as condensers and low temperature heat exchangers. Entrapment of foreign materials in the slime swells the accumulation on the heat exchange surface. Preventive measures of continuous or intermittent chlorination treatment may be used to maintain operation at peak efficiency.

Many chlorinators are solution-fed vacuum machines. The chlorine is regulated and metered by a partial vacuum created by an aspirator injector. At the injector, chlorine is mixed with water and then discharged. Operation of most boiler feedwater chlorinators are automatic. Condenser chlorinators can be controlled manually, semiautomatically, or intermittently programmed to stop and start. Continuous chlorination systems feed chlorine at a rate of 1 to 3 parts per million, while intermittent feed systems feed chlorine at a rate of 5 to 10 parts per million.

Most large plant chlorinators feed the chemical in the liquid form, although some may be gas-fed. Chlorine is an extremely dangerous material. Chlorine cylinders should never be bumped violently or dropped. Chlorine cylinders containing liquid chlorine should be kept away from a flame, and its temperature should be kept below 100 °F.

Flocculator

The flocculator is used in conjunction with chemical coagulants. Chemicals, such as potassium, ammonium alum, lime, or other coagulants, are introduced into a basin with the makeup water. These coagulants, along with rapid mixing, promote the joining of suspended material to form larger, denser particles called floc. The flocculator is a slow mixing machine. This allows forming floc particles and suspended material to collide and grow larger.

A flocculator consists of motor-operated paddles rotated by a central shaft. Rotation can be through a vertical or horizontal plane. Many different flocculator designs are available, but all use the principle of agitating the water to increase floc particle size.

Flocculation time varies between 20 minutes and 1 hour. The size and speed of the paddle should be designed to limit the tip speed to less than 1.2 feet per second. After leaving the flocculation compartment, the water velocity should not be higher than the flocculating velocity, otherwise the floc may break up and not reform. After the water and floc leave the flocculation compartment, they flow to the settling basin where the floc settles to the bottom and the treated water can flow out.

Clarifier

The clarifier is used in conjunction with coagulants and some degree of flocculation. Chemical coagulants are introduced into the makeup water. After the flocculator increases the size and density of the floc, the flow moves to the clarifier. The clarifier is used to separate the floc particles from the treated water.

The clarifier consists of a set of small inclined tubes. The water flows horizontally beneath the tubes. The tube sets are placed in the upper portion of the basin, therefore the only path for the water to take is upward through the tubes. If the upward velocity of the water is less than the settling velocity of the slowest settling particle, all the floc will settle inside the surface of the tubes. The treated water flows out through the top of the tubes and is collected by flumes, while the floc particles increase in size and fall out the bottom of the tubes and settle to the bottom of the basin.

If the clarifier is inclined at an angle that exceeds the angle of repose of the settled material, the clarifier's basin will become self flushing. The sludge will slide back out the entrance of the device.

Laminar flow is necessary for efficient operation of the clarifier because convection currents in turbulent flow will redistribute any solids that settle. Laminar flow is maintained at high flow rates in small tubes by the increased drag effect of the relatively large surface area. The flow rate for these clarifiers should be between 2 and 5 gpm per square foot of cross sectional surface area.

Gravity Filter

Filters use a porous medium to remove suspended solids. The gravity filter uses gravity alone to pull the water through the filter medium. At the bottom of the filter case is the underdraining system. This collects filtered water and dispenses the backwash water, used to clean the filter material. On top of the underdraining system is a bed of coarse anthracite or gravel. On top of this bed is a 24 to 36 in. of filter material, usually sand or fine anthracite.

Water enters through the top of the unit and moves down through the filter medium. The water then flows through the underdraining system and into the filtered-water basin. The process is reversed when cleaning a unit. The water flows up through the underdraining system and then through the filter medium. Solid waste material collected from the filter is discharged into troughs and then taken to the sewer.

Filtering water flow rates range from 2 to 5 gpm per square foot of filter area. The backwashing, or cleaning, flow rate range from 15 to 25 gpm per square foot of filter area.

As time passes, the efficiency of a filter is increased. Flocculated material fills the void between filter material, and this coating forms small interstices and contributes to the removal of both soluble and suspended solids.

Pressure Filter

The pressure filter uses relatively high pressure (50 to 100 psi) to force the water through the filter medium. The pressure filter has the same basic structure as the gravity filter. At the bottom is an underdraining system and on top of that is a bed of 8 to 20 in. of coarse gravel. On top of the gravel bed is a bed of filter medium, sand or anthracite, usually 18 to 36 in. deep. Among the most common impurities removed by a pressure filter are iron, dirt, oil, and color. Pressure filters can be set up as a vertical or a horizontal unit. Vertical units work best, but they cannot handle a large flow.

In most pressure filters, water enters the top of the unit and is distributed by a perforated pipe or a trough. The water is filtered down through the filter medium and through the gravel bed and is collected in the underdraining system before being discharged. The flow is reversed to clean the unit.

In some pressure filters, a coagulating tank is placed before the filter unit. This improves the filtering process by increasing the waste particle size.

Filtering water flow rates range from 2 to 5 gpm per square foot of filter area. Horizontal pressure units can handle over 1,000 gpm. Some horizontal units use separating vertical baffles. This helps stop the filter bed from moving around and increases filtering efficiency.

Carbon Filter

Carbon filters can be either gravity or pressure type. In a carbon filter, the medium is an activated carbon. The filter unit itself is no different from the gravity filter unit or the pressure filter unit, except the carbon filter units are lined with an anticorrosive protective coating. Carbon filters are used to remove foreign odors and tastes. These filters will also remove chlorine, phenols, and chlorophenols from the incoming water. The activated carbon will actually absorb these chemicals. Backwashing is still necessary to remove the suspended particles filtered out by the carbon medium.

Sludge Contact Softener

Contact sludge softener units operate on the principle that precipitate, in the form of sludge, will form when a supersaturated solution flows through a contact medium. Untreated water mixes intimately with precipitated sludge. When coagulants are added, the precipitates form and enter the sludge pool of previously formed precipitates. The sludge permits treated water to be separated from the raw untreated water. If the unit is working correctly, a line of separation exists between the sludge bed and

the treated water. The sludge bed acts as a filter and the treated water is filtered through a bed of its own sludge. The sludge bed is slowly circulated to maintain the intimate contact between untreated water, coagulants, and the precipitated sludge.

The sludge contact softener removes suspended solids and some dissolved solids. These units are capable of treating 1 to 3 gpm per square foot of sludge contact area. The normal retention time for sludge contact softener is 1 to 2 hours. The filtering of the untreated water through the sludge bed also reduces the hardness of the water more than a sedimentation tank.

Hot Process Softener

Hot process softeners are designed to operate at temperatures above 200 °F. They are able to treat a lot of makeup water in a relatively small space. The process uses steam to reduce the dissolved gases in the untreated water, while a coagulant is used to separate out the dissolved and suspended solids.

Untreated water flows through a metering orifice and an inlet valve that is actuated by the level of the treated water in the bottom of the softener. The water is sprayed into the softener at the top, while the coagulant is introduced under the spray. The spray produces small droplets of water that are heated to within a few degrees of its steam temperature by steam supplied at the upper portion of the softener. Heating the spray releases the oxygen and carbon dioxide in the incoming water. The water flows down the softener. At the bottom of the softener is a sedimentation tank and just above this is an uptake funnel. As the water flows down, it flows around the rim of the funnel, where the density of the precipitate and the change in direction separates the water from the precipitate. The treated water flows through the uptake pipe, back to the top of the softener to another deaerating heater. The steam entering the heater atomizes the water and removes any traces of dissolved gases. This water is drawn through filters and out of the softener to the boiler feed pumps. The filters are backwashed with the treated water and the backwashed water is returned to the softener unit.

A retention time of about 1 hour is required in the sedimentation tank before water is drawn through the uptake funnel. The high operating temperatures produce optimum efficiency of the coagulants and recirculating the softener sludge can save money on chemical coagulants.

Sodium Zeolite Softener

Sodium zeolite softening is accomplished by passing untreated hard water through a bed of cation resin that can remove the hardness, calcium, and magnesium, and replace it with the sodium ion. Calcium and magnesium will be removed rapidly from their salts, bicarbonates, sulfates, and chlorides. These ions are exchanged very rapidly, so even very hard water can be almost completely softened. The resin has a limited amount of sodium ions it can exchange. The Operating Exchange Value is the point where the ion exchange becomes inefficient and the resin must be regenerated. Regeneration is replacing the sodium ion to the resin and taking the exchanged calcium and magnesium ions away and is accomplished by passing a brine solution through the bed of resin material. Once the resin is regenerated, the unit is again capable of softening water.

Sodium zeolite softeners can operate as gravity or pressure types, very similar to gravity or pressure filters. Gravity softeners are used for large systems. These softeners can be either vertical or horizontal, but vertical is the preferred position. Horizontal units are used for very large flows.

At the bottom of the softener is the underdraining system, used for collecting water through the bed and for backwashing. In zeolite softeners, this underdraining system is constructed of corrosion resistant material because of the corrosive properties of brine and hard water. The underdraining system is covered with gravel or coarse anthracite. This supports the ion-exchange resin bed. Backwashing removes deposits on the resin bed and is done just before brining. After brining, rinsing is performed to remove salt from the equipment.

Zeolite softening rates vary from 3 gpm to 10 gpm per square foot of bed area. Gravel or anthracite bed depth should be from 12 to 24 in. deep. The resin bed depth depends on the softener flow and desired time between regenerations, but is usually between 30 and 72 in.

Dealkalizer

Dealkalizing is accomplished by passing untreated alkaline water through a bed of strongly basic anion resin that can remove the bicarbonate, carbonate, sulphate, and nitrate ions and replace them with chloride ions. This process is called salt splitting. After the resin has reached its exchange limit, it is regenerated with either brine solution or a mixture of brine and caustic soda. Regeneration replaces chloride ions to the resin and carries away bicarbonate ions. Once the unit is regenerated, it can again dealkalize the water flow.

The construction and operation of a dealkalizer is almost identical to that of the sodium zeolite softener. The largest difference in the two units is the strongly basic anion resin used in the dealkalizer and the cation resin used in the softener. The dealkalizer also has the option of adding a small amount of caustic soda to the brine solution during regeneration.

The water flow rates for dealkalizers vary from 4 to 8 gpm per square foot of resin area. When caustic soda is added to the brine solution, it should be added in proportion to the brine to produce a regenerant solution that is between 0.5 and 1.0 percent caustic soda and about 10 percent salt.

Zeolite softeners and dealkalizers often are used in tandem. When they are used together, it is important that the dealkalizer is downstream of the softener because the dealkalizer cannot remove hardness and should not have hard water passed through it. Also, it is important to only use soft water during dealkalizer regeneration.

Hydrogen Zeolite/Sodium Zeolite Split Stream Softener

This softening system consists of a sodium zeolite softener and a hydrogen zeolite softener. Water flows through these two units in parallel and the treated water is blended together to produce water with the needed alkalinity. A description of the sodium zeolite softener and its operation was given in a previous section.

The hydrogen zeolite softener uses a bed of strongly acidic cation exchange resin to remove the calcium, magnesium, and sodium ions from the water and replace them with hydrogen ions. The unit is regenerated with acid, usually sulfuric acid. The hydrogen zeolite's regeneration rate is usually between 0.5 and 1.0 gpm per cubic foot of resin. The sulfuric acid is in a concentration of 2 to 6 percent acid. The acid exchanges hydrogen ions back to the resin and removes the hardness ions. The construction and operation of the hydrogen softener is almost identical to that of the sodium zeolite softener, except the hydrogen softener uses rubber or other corrosion resistant material in its construction.

The water produced by the hydrogen and sodium softeners are low in calcium and magnesium. The sodium zeolite water is high in sodium salts and the hydrogen zeolite produces a water high in acids. The sodium zeolite alkalinity is used to neutralize the acids from the hydrogen zeolite softener. The sodium alkalinity is converted to carbonic acid, which is removed from the water by a degasifier. The alkalinity of the mixture is controlled by varying the ratio of the sodium and hydrogen zeolite water in the blend. The blending control is usually a simple rate-of-flow controller, but for

better control of the alkalinity, automatic analyzers can be used to compensate for changes in the incoming water.

Reverse Osmosis Unit

Osmosis is a process that separates a salt solution and pure water by using a semi-permeable membrane. The pure water diffuses through the membrane and dilutes the salt concentration. The difference in the salt concentration is the driving force behind this process; pure water flows through the membrane as though a pressure were being applied to it. This force is called the osmotic pressure. The osmotic pressure depends on the salt concentration and the water temperature, and is approximately equal to 1 psi per 100 ppm of totally dissolved solids. When pressure sufficiently greater than the osmotic pressure is applied to the saline side, the osmosis process is reversed and fresh water flows across the membrane from the saline side to the pure water side.

Most membranes are made of very fine plastic fibers that measure 85 to 250 microns in diameter. These fibers are very closely packed and can provide a very large surface area in a relatively small volume. The filter can have several different configurations such as flat, tubular, spiral, or hollow fibers. For non-flat filters, the untreated water is introduced into the center of the fiber mass and the treated water flows radially outward.

The filter membrane does undergo some fouling, but it can be minimized if the pressure is less than 400 psig and the temperature is less than 77 °F. Most reverse osmosis units require water pretreatment such as chlorinators, filters, softeners, and dealkalizers. Filter membrane life depends on the operating pressure and can range from a few months to 3 years.

Degasifier

A degasifier is used to remove dissolved gases in the makeup water supply. There are two types of degasifiers: forced draft and vacuum units. Both methods use the same procedure; air flowing over thin sheets or small droplets of water in a counterflow configuration to remove the carbon dioxide and oxygen from the water.

Water is delivered at the top of the unit and distributed over perforated plates, slats, or steps to break up the water and provide a larger surface area. The water falls vertically to a storage reservoir at the bottom of the unit, which is water-level regulated. Air enters near the bottom of the unit and flows up through and over the water to the top where it and the released gases leave the unit. A forced draft unit uses a forced draft fan at the air inlet to force the air through the unit. A vacuum

degasifier uses a vacuum at the top of the unit to collect the released gases and pull the air through the water flow.

Degasifiers can be cylindrical or rectangular units and their size and capacities are almost unlimited. Forced draft degasifiers are favored in most water treatment situations because of their uniform air distribution across the entire cross section. Forced gas units are more efficient for gas removal and require less space for a given capacity.

Demineralizer

Demineralization is the process of removing inorganic salts by ion exchange. This process uses hydrogen cation exchange to convert dissolved salts to their corresponding acids, and basic anion exchange to remove these acids. The demineralizer system consists of an ion exchange column, which contains at least one acidic cation exchange resin and at least one anion exchange resin. The cation resin exchanges a hydrogen ion for the metallic ion of salts to form an acid. The anion resin exchanges a hydroxyl ion for the sulfate, nitrate, and chloride ions. Demineralizers that must remove silica use a strongly basic anion resin, but if silica removal is not a priority, a weakly basic anion resin is used. Mixed bed demineralizers, an intimate mixture of strongly acidic cation and strongly basic anion resins, are used for systems that demand water of extremely high purity.

The cation exchange units are regenerated with an acid similar to that in a hydrogen zeolite softener. The anion exchange units use caustic soda for regeneration, but weakly basic units can use ammonia or soda ash for regeneration. Mixed bed demineralizers require the anion and cation resin bed to be separated before regeneration. Backwashing the unit should accomplish this. A distinct line of separation should appear. The unit can be regenerated normally after separation, with the acid introduced at the bottom of the unit and the caustic added at the top of the unit. A mixed bed demineralizer can be regenerated external to the unit. This provides nearly continuous service from one unit.

The cation and anion exchange units used in demineralization are very similar to hydrogen zeolite softeners and other ion exchange units. If a system has more than one acidic column and one basic column, a degasifier is usually used in between. This can be a forced draft degasifier or a vacuum unit. Demineralizers vary in flow capacity from 3 to 8 gpm per square foot of resin surface area. Similar to other ion exchange equipment, demineralizers function well only if the water supply is free of suspended matter and oxidizing materials, so other water treatment equipment may be used upstream of the unit.

Evaporator

An evaporator changes makeup water to steam and then condenses the steam in another chamber. When the water is converted to steam, dissolved or suspended solids in the water remain in the distilling chamber creating purer water in the condenser chamber. Well-designed and operated evaporators can produce condensate having less than 2 ppm solids content.

There are four major types of evaporators used for makeup water service. The first design is a submerged-tube evaporator. Here the water is heated by live or exhaust steam passing through submerged coils in a water reservoir. The second type of evaporator is a film evaporator. In this design, the water is filmed over a series of steam coils. These coils are enclosed in a cast iron or steel shell where the water flashes to vapor. A third evaporator style is the flash evaporator. A tubular heater is used to increase the makeup water's temperature high enough for it to flash to vapor when it enters the flash tank, which is maintained in a vacuum state. The last design is a multiple-effect evaporator. Here, a number of evaporator units are placed in series. The vapor in one unit is used to heat and vaporize the makeup water in the next unit following it. The vapor coils in each unit act as a condenser for the unit preceding it. The first three designs mentioned all used an external condenser.

Low pressure evaporators produce more sludge than high pressure units and should be cleaned every 300 to 700 hours for sea water evaporators and every 2,000 to 3,000 hours for fresh water systems. High pressure evaporators form a much harder, denser scale that can be removed by placing the shell under a vacuum.

Water should be pretreated before being vaporized in the evaporator. Chlorinating, filtering, softening, and degasifying should all be completed prior to evaporating.

Condensate Polishing

Oil Removal Polisher

Oil may seep into the condensate from pumps and other machinery and must be removed. The oil found in the condensate is often emulsified; this gives the condensate a milky appearance. The oil in the condensate may be absorbed by diatomaceous earth filters, but the condensate may pick up silica from the diatomaceous earth. A more accepted method is an anthracite filter bed with preformed floc added. The floc breaks up the oil and the filter reduces the oil to a small amount. The floc is prepared by mixing two parts alum sulfate and one part soda ash or caustic soda. If the conden-

sate's pH value is above 9, iron sulfate is substituted for the alum sulfate. The floc is injected on the filter bed to make a mat. About 0.2 pounds of alum sulfate per square foot of filter area will make the mat. A small amount of floc is introduced continuously while the filter is in use; about 0.5 ppm of alum sulfate per 1 ppm of oil is sufficient.

The filter flow rate varies between 3 and 5 gpm per square foot of filter area. The filter is able to remove about 50 ppm of oil. Deep penetration of the oily floc into the bed should be avoided.

Diatomaceous Earth Filters

Diatomaceous earth filters use a fabric or ceramic filter that is suspended by a rigid core or bracket within a pressure filter. Before filtering begins, a precoat cycle must take place. A measured amount of diatomaceous earth, about 0.1 pound per square foot of filter area, is loaded into a precoat tank, which is a small pressure vessel. Filtered water is flushed through the tank and enters the filter region. The diatomaceous earth particles bridge the opening of the fabric filter and form a microscopic filter. The diatomaceous earth cake is then the filter medium with the filter element acting as the support. The filter's water flow rate varies from 2 to 4 gpm per square foot of filter area.

During the precoating operation, a small amount of diatomaceous earth will bleed through the fabric filter until larger particles are able to bridge the openings and trap the finer particles. Because of this, the precoating flow is recirculated or run to waste for 2 to 3 minutes, or until the filtered water runs clear.

When the filter is in operation, the unfiltered water is introduced at the bottom of the unit. The water rises and passes through the precoat material, and eventually to the upper chamber and out of the unit.

When the fabric filter becomes too clogged, the unit is backwashed with high pressure water to dislodge the diatomaceous earth cake. The dislodged cake is then washed out the bottom of the unit and precoating is started again.

These filters come in two different designs, tubular filters and leaf filters. There is little difference between these two types of units, except the shape of filters and the paths of the entering water.

Sodium Cycle Polisher

Sodium cycle condensate polishers are used for high boiler pressure applications, usually where boiler operating pressures exceed 1,000 psig. A sodium cycle polisher is almost identical to sodium zeolite softeners, except the polisher is designed for a higher water flow rate, varying from 20 to 25 gpm per square foot of resin bed area. The high flow rate promotes filtration of suspended solids while the ion exchange process is under way.

A potential problem in this unit stems from the removal of amine, used as a corrosion inhibitor, in the polisher. Once the resin reaches its exchange capacity, it releases the amine, in the form of amine bicarbonate, and this flows to the boiler. In the boiler, about 90 percent of this will break down into carbon dioxide, which is carried away with the steam. This carbon dioxide can cause corrosion of the steam distribution system.

The sodium cycle condensate polisher needs to be regenerated with a brine solution after a period of service, similar to the sodium zeolite softener.

Compressed Air System

The compressed air system in the plant will provide air for controls, process air uses, and, in some cases, provide air for sootblowers and oil atomization. The system will consist of air compressors, air dryers, air receivers, and interconnecting piping. The air compressor will generally be an electric motor driven reciprocating, rotary screw or, in larger sizes, a centrifugal compressor.

The air dryers will usually be either the desiccant type or the refrigerated type. The desiccant type will provide a lower dew point air than a refrigerated type and is generally used for instrument air that needs to be dryer or for air that will be routed outdoors in cold climates.

Air receivers will be installed to store the compressed air and allow cycling rather than continuous operation of the compressors. The air receivers are carbon steel pressure vessels and may be fitted with automatic devices to drain any condensing water.

Electrical System

The electrical system will usually be fed from the base distribution system or the utility. The feed will enter the plant at a distribution voltage, typically 34,500, 12,500, or 4160 volts. The feeder will include fused disconnects and will supply the plant transformers. The plant transformers will step the voltage down to a usable voltage, usually 480 volts. Large plant motors and loads may operate at a higher voltage, such as 2400 or 4160 volts, for improved efficiency. From the transformers, the feed will go through switchgear to feed the motor control centers. The motor control centers hold the motor starters and other motor control devices. Most central heating plants will have an emergency generator installed to provide a minimum power supply during utility outages. The generator is usually a diesel motor driven unit and generates electricity at the plant voltage.

Coal Handling Systems

Rail Hoppers

Rail hoppers, located below railroad tracks or roadway, serve as the coal receiving equipment and as temporary coal storage. The top of the rail hopper includes a grizzly (or grill) to prevent oversized lumps of coal from entering the hopper. One or more rail hoppers may be installed at a central heating plant site. Coal may be delivered to the plant by rail cars or trucks.

Track Hopper Valves

The rail hoppers will be equipped with a track hopper valve at the hopper discharge to stop or control the flow of coal from the hopper. The valve will typically be a knife-type gate and can be equipped with manual hand wheel operators. Electric motors, hydraulic, or pneumatic operators are available as options.

Carhoe

The carhoe is a hydraulically operated spade used to unload frozen coal from rail cars and break up frozen coal lumps that are too large to pass through the grizzly.

Car Puller

Car pullers are used to position loaded coal cars above the track hopper. Small models are generally used for positioning single cars. Larger models can be used for positioning multiple rail cars for unloading.

Coal Car Thawing Equipment

Special equipment for unloading frozen coal will depend on the location and size of a central heating plant. Only plants located in areas where below freezing temperatures are experienced for an appreciable part of the year should consider installating this type of equipment.

Several mechanically operated methods for unloading frozen coal have been developed and operated successfully. The most reliable and efficient method is a steam-heated thawing shed. However, new installations are seldom made since they are very expensive. Other methods such as oil- or propane-fired thawing pits, arranged to heat the bottom of the cars without flame impingement, give quite rapid and reliable results. Radiant-electric type railroad car thawing systems have also been used effectively at many power plants handling unit-train shipments of coal.

For smaller plants, expensive equipment is not economically justifiable, and the methods depend primarily on manual labor. Slice bars, sledges, portable oil torches, and steam or hot water, as well as the previously described Carhoe are the tools commonly used.

Vibrating Feeders, Volumetric Type

This type of coal feeder typically is used to transfer coal from hoppers, such as track rail hoppers or coal pile reclaim hoppers, to various types of coal conveyors. The feeder consists of an electromagnet that operates at 3600 cycles (vibrations) per minute, a trough that receives and conveys the coal, and controls that operate the feeder. The electromagnet's vibrations are transmitted to the trough causing it to move rapidly back and forth. The control system provides start/stop capability and controls flow rate by varying the intensity of the vibrations.

Frozen Coal Crushers

Coal received at a central heating plant located in northern latitudes or coal received from northern latitudes may arrive frozen into large lumps in the rail car. A frozen coal crusher, if required, would typically be installed beneath the rail hopper. Frozen

lumps of coal entering the crusher are reduced in size by a combination of impact from the rolling hammers and compression as the ring hammers force the lumps through the screen plate.

Open Coal Storage Area

Coal will be stored on-site for use in the central heating plant. An outdoor coal pile typically will be built on a paved area of the site or may alternately be built atop a clay lined area of the site. In either case, a minimum of 90 days storage, based on full load operation of the central heating plant will be required. The coal storage area will be enclosed by a barrier wall and will include an underdrain system to collect rain water runoff for treatment prior to discharge.

Coal Silos

Coal silos are typically constructed of vitrified tile blocks with reinforcing bands, concrete staves, or reinforced concrete. Approximately 30 days storage is required, based on full load operation of the heating plant. Each silo would be equipped with a system to collect dust generated during filling operations. The silo's outlet is located high enough above grade to permit installation of equipment to transfer coal to individual coal bunkers in the plant.

Belt Conveyors

Belt conveyors are used to move coal from the rail hoppers to long-term storage areas (open storage or silos), from storage areas to coal crushers, and to in-plant bunkers or bins. A typical belt conveyor consists of multiple rows of roller bearing idlers, which cause the conveying belt to form a trough, return idler rollers, the conveyor belt, a drive motor and gear reducer, a belt take-up device to maintain tension on the belt, and a support structure to support and maintain the alignment of the above components. A belt cleaner may also be included.

Belt conveyors can be installed to operate in a horizontal plane or may be inclined (up to 15 degrees from horizontal) for conveying coal. The entire conveyor may be exposed, or may include covers for the belt and rollers, or the entire conveyor may be enclosed in a gallery.

Screw Conveyors

Screw conveyors are one of the oldest and simplest methods of moving bulk materials such as coal. The conveyor consists of a conveyor screw that rotates in a stationary

trough. Coal placed in the trough is moved along its length by rotation of the screw, which is supported by hanger bearings. Inlets, outlets, gates, and other accessories control the disposition of the coal. The screw is rotated by a shaft-mounted gear reducer driven by an electric motor. Modified screw conveyors are also used as feeders.

En Masse Conveyors

An en masse conveyor consists of a flighted, endless chain contained in a dust tight casing. The casing includes a dividing plate to separate the supply and return portions of the flighted chain conveyor. Material, such as coal, placed in the conveyor, moves as a solid column through the length of the conveyor. There is virtually no turbulence of the material as it is carried to the discharge point or points.

The equipment is driven by an electric motor driving a gear reducer mounted at the head end of the conveyor. En masse conveyors can be used to move coal in a vertical or horizontal plane or can form a continuous loop with many feed and discharge points.

Bucket Elevators

Bucket elevators consist of a series of buckets attached to a belt or chain, sprockets, pulleys, bearings and take-up, all enclosed in a dust tight casing. The elevator is operated by an electric motor driving a shaft mounted gear reducer at the head (or discharge) end of the elevator. Bucket elevators are typically used to elevate coal to silos at sites with limited space, or where the silos are adjacent to the rail hoppers.

Dense Phase Pneumatic Conveyors

The following components constitute the basic hardware for a dense phase pneumatic conveying system: transport pressure vessel, vibrating feed hopper with operator and controls, slide gate, automatic material inlet gate or valve (dome valve), air inlet (solenoid) valve, automatic pinch valve, low pressure air switch, compressed air line accessories (such as pressure regulating valve, filter lubricator, pressure gauges, and check valves), pressure vessel, air blend ring, conveying pipe, long radius bends, two-way line switch valves, two-way silo dump or discharge valves, terminal box, bin vent filter units of the pulse jet automatic type, graphic control panel, and level indicators.

Magnetic Separators

Two types of magnetic separators are commonly used in coal-fired plants to remove tramp metal from the belt conveyor carried coal streams. The first type uses a magnetic head pulley on the belt conveyor. As the tramp iron contaminated material

comes within the pulley's magnetic field, the tramp iron is attracted and held to the belt as it passes over the pulley. As the tramp iron passes under the pulley and leaves its magnetic field, it falls from the belt and is discharged separately from the coal.

The second commonly used magnetic separator is the suspended type, which may use either a permanent or electromagnet to achieve separation. Suspended magnetic separators may simply be a magnet (requiring manual cleaning) or may be equipped with a belt to convey the tramp-iron away from the coal conveyor to a separate discharge point.

Metal Detector

Metal detectors are installed on coal belt conveyors to detect the presence of tramp metal fragments that could damage equipment such as coal crushers. The passage of tramp metal through the detectors field generates a signal that may be used to stop the conveyor, sound an alarm, or activate a marking system that indicates the location, on the belt, of the tramp metal.

Belt Coal Scales

The major components of a belt coal scale include a console that displays flow rate in tons per hour, the total amount conveyed, and the grand total amount of coal conveyed; a weighing unit that replaces one or more of the conveyors idlers; and a belt speed sensor.

The weighing unit includes a load receptor with adjustable idlers and a mechanical device for transmitting belt displacement to a strain gauge transducer. Belt speed is measured by an optoelectronic sensor with a drive shaft whose rotational speed is proportional to the belt speed.

Coal Valves

These valves, which control the flow of coal from bins or hoppers, can be of the knife gate or clamshell types. These valves can be equipped with manual handwheels, electric motor, or pneumatic or hydraulic operators.

Blade Diverter Valves

Blade diverter valves are used to divert the flow of fast-moving materials falling through a chute. In coal-fired plants, these valves are used to divert coal flow to

bypass chutes around belt feeders or coal crushers. Blade diverter valves, as well as the similar swinging hopper diverter valve, are available in a variety of configurations.

Spouts and Chutes

Spouts and chutes can be of round or rectangular configuration and serve to direct the flow of coal from bunkers and bins to and from other equipment in the coal handling system.

Coal Feeders

A variety of types of coal feeders are available for use in coal-fired heating plants. However, all feeders fall into one of two general types: volumetric and gravimetric.

In a typical gravimetric batch type feeder, coal entering the feeder is carried by an integral belt conveyor to a hopper mounted on load cells. When the weight of coal in the hopper reaches a preset value, the belt stops and the hopper is emptied by opening a bottom hatch. The bottom hatch then closes, the integral belt conveyor restarts and the process is repeated. The belt conveyor can also be retracted to allow by-passing of the belt and hopper and feed coal directly to the stoker or other equipment. In a belt type volumetric feeder, the coal feed rate is controlled by raising or lowering the leveling bar. The leveling bar limits the depth of coal on the belt. Also included are paddle type alarm switches to indicate coal stoppage both before and after the feeder, and belt scrapers.

Coal Bunkers and Bins

In-plant bunkers and bins provide the final coal storage just before the coal is fed to the boiler. Coal bins can be of round or rectangular configuration and generally serve a single boiler. Plants with multiple boilers require multiple bins. Coal bunkers are designed to serve multiple boilers. A single bunker may be over 100 feet long and supply coal to three or four boilers from multiple outlets. Bunkers can be of either straight sided or catenary type design.

Coal Pipes and Valves

Coal piping and valves are used to direct the flow of coal to and from bunkers and bins and to and from other equipment such as feeders or stokers.

Air Cannons

Air cannons are high-energy, low-frequency devices driven by compressed air. When activated with compressed air (at 70 to 100 psig), the air cannon produces a sound pressure wave with sufficient vibrational energy to dislodge particles of material from the surfaces to which they cling. Air cannons can be used as sootblowers, in boilers, in economizers, precipitators, baghouses, induced draft fans, ductwork and breeching, hoppers and bins, and mechanical dust collectors or any equipment where dust buildup occurs.

Coal Belt Tripper

A coal belt tripper is installed on horizontal coal conveyors and used to fill coal bunkers or bins. The belt tripper has the ability to discharge coal from the belt either to the right or left or can reload coal back onto the conveyor. These machines can be operated while stationary or while moving along the belt conveyor.

Conical Nonsegregating Distributors

This coal chute is specially designed to transfer coal from bunkers or bins to the mechanical stoker equipment. The designed shape of the distributor prevents the separation of coal into coarse and fine particles as occurs with flat distributors.

Combustion Controls

Combustion controls regulate the amounts of fuel and air entering the furnace to match the boiler or hot water generator demand. For boilers, steam pressure, which varies with changes in demand, serves as the input signal by which the firing rate is controlled. In hot water generators, the water temperature leaving the boiler is used as the input signal. Boilers with induced draft fans or tall stacks also require control of furnace draft by adjustment of induced draft fan inlet dampers or boiler outlet dampers. Two types of combustion controls are normally used for stoker coal-fired boilers: parallel positioning and series/parallel controls.

Parallel Positioning Controls

A change in steam pressure or hot water temperature from the set point results in the master controller signalling the fuel, combustion air, and overfire air actuators to reposition themselves to the new firing rate. Two fuel/air ratio control stations are used to adjust and trim the combustion air and overfire air supplies. A furnace

pressure controller adjusts the induced draft fan inlet damper or boiler outlet damper to maintain a slightly negative pressure in the furnace.

Series/Parallel Controls

Fuel feed rate is controlled based on steam pressure and air flow is controlled based on steam flow. A combination air-flow and steam flow meter is used as a guide for the operator to control the relationship between the amount of air required to burn the coal fuel and the amount of air actually supplied. The steam generation rate is used as a measure of the air required while the flow of gases through the boiler is used as a measure of the air actually supplied.

Spreader stokers require close control of both fuel and air supplies since part of the fuel burns in suspension. Grate burning stokers, including both mass burn and underfeed types, respond well to changes in air flow rates. Small underfeed stokers handling relatively steady heating loads may be operated by simple start/stop controls.

Auxiliary Fuel Firing Controls

These control systems are the same as previously described. Army Technical Manual TM 5-650, *Central Boiler Plants*, provides an excellent description of combustion control systems for stoker-fired as well as gas/oil-fired central heating plants.

Stacks

Stacks (generally of steel construction) and chimneys (generally concrete or masonry construction) are used to discharge the flue gases from fuel combustion well above ground level, thereby allowing dilution and dispersion of these flue gases. Stacks can be of single-wall or insulated double-wall construction, and include accessories such as a caged ladder or other climbing safety device, test ports, painters ring, and obstruction lights or beacon.

Chimneys

Chimneys may be constructed of a concrete shell with one or more internal brick flues, or may be constructed of brick. Accessories are similar to those for stacks.

Fire Protection Systems

In general, typical fire protection systems for fossil fuel central heating plants can be classified as water systems or carbon dioxide systems. Halon systems are also used. Water systems are further classified as wet or dry.

In the wet system, virtually all fire piping is filled with water, while in the dry system the piping does not contain water. Normally, wet systems are installed in buildings or heated spaces not subject to freezing while dry systems are used where freezing may occur.

Dry systems may be open or may be filled with compressed air. With either an open or compressed air filled system, a fire alarm or detector will activate a valve allowing the system to flood with water.

Carbon dioxide (CO_2) systems include both permanent and portable fire extinguishers. Permanent systems consist of CO_2 supply tanks, piping, valves and nozzles, fire detectors, and alarms and controls. Portable extinguishers are manually operated and should be included for all systems to provide complete protection. Halon systems are similar.

Included with the fire protection systems are various fire detection devices for smoke, carbon monoxide, methane and heat, as well as manual and automatic alarms and annunciators.

National Fire Protection Association Code 850, *Recommended Practice for Fire Protection for Fossil Fueled Steam Electric Generating Plants*, presents criteria for design of systems as well as a recommended inspection, test, and maintenance schedule.

Appendix B: Database File Structures

Field	Field Name	Type	Width	Dec
Structure for database: <basecode>DATA.DBF				
1	SYSTEM	Character	10	
2	ITEM	Character	12	1
3	SPEC1	Numeric	8	1
4	SPEC2	Numeric	8	1
5	SPEC3	Numeric	8	
6	NUMUNITS	Numeric	6	
7	YRINSTAL	Numeric	4	
8	YRREPLACE	Numeric	4	
9	COSTREPL	Numeric	10	
10	CONDITION	Numeric	1	
11	YRDOLLARS	Numeric	4	
12	EXPLINDEX	Character	6	
** Total Bytes			82	
Structure for database: <basecode>EXPL.DBF				
1	INDEX	Character	6	
2	YREXPL	Character	70	
3	COSTEXPL	Character	70	
** Total Bytes **			147	
Structure for database: VALID.DBF				
1	SYSTEM	Character	10	
2	ITEM	Character	12	
3	UNIT1	Character	12	
4	UNIT2	Character	12	
5	UNIT3	Character	12	
6	VAL MSPEC1	Character	40	
7	VAL MSPEC2	Character	40	
8	VAL MSPEC3	Character	40	
** Total **			179	
Structure for database: DEFAULT.DBF				
1	SYSTEM	Character	10	
2	ITEM	Character	12	1
3	SPEC1	Numeric	8	1
4	SPEC2	Numeric	8	1
5	SPEC3	Numeric	8	
6	COST	Numeric	7	
7	COSTYR	Numeric	4	
8	LIFESPAN	Numeric	2	
** Total Bytes			60	

Appendix C: Data for DEFAULT.DBF

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
APC	COLLECTOR	25000.0	0.0	28000	1991	40
APC	COLLECTOR	50000.0	0.0	43000	1991	40
APC	COLLECTOR	75000.0	0.0	55000	1991	40
APC	COLLECTOR	100000.0	0.0	69000	1991	40
APC	COLLECTOR	150000.0	0.0	83000	1991	40
APC	BAGHOUSE	25000.0	0.0	300000	1991	40
APC	BAGHOUSE	50000.0	0.0	500000	1991	40
APC	BAGHOUSE	75000.0	0.0	550000	1991	40
APC	BAGHOUSE	100000.0	0.0	800000	1991	40
APC	BAGHOUSE	150000.0	0.0	1000000	1991	40
APC	PRECIP	25000.0	0.0	700000	1991	40
APC	PRECIP	50000.0	0.0	1100000	1991	40
APC	PRECIP	75000.0	0.0	1400000	1991	40
APC	PRECIP	100000.0	0.0	1600000	1991	40
APC	PRECIP	150000.0	0.0	2000000	1991	40
APC	BREECH	3.0	0.0	550	1991	40
APC	BREECH	4.0	0.0	740	1991	40
APC	BREECH	5.0	0.0	925	1991	40
APC	BREECH	7.5	0.0	1400	1991	40
APC	BREECH	10.0	0.0	1900	1991	40
APC	STACK	3.0	50.0	10000	1991	40
APC	STACK	4.0	50.0	15000	1991	40
APC	STACK	5.0	75.0	25000	1991	40
APC	STACK	6.0	100.0	40000	1991	40
APC	STACK	8.0	100.0	80000	1991	40
APC	ASHCONV	1.0	0.0	50000	1991	25
APC	ASHCONV	5.0	0.0	85000	1991	25
APC	ASHSTOR	5.0	0.0	7000	1991	25

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
APC	ASHSTOR	10.0	0.0	13000	1991	25
APC	OPACMONITOR	0.0	0.0	25000	1991	30
APC	SCRUBBER	25000.0	0.0	6800000	1991	40
APC	SCRUBBER	50000.0	0.0	10300000	1991	40
APC	SCRUBBER	75000.0	0.0	13200000	1991	40
APC	SCRUBBER	100000.0	0.0	15700000	1991	40
APC	SCRUBBER	150000.0	0.0	20000000	1991	40
APC	CSTEEL STACK	3.0	50.0	71000	1992	40
APC	CSTEEL STACK	5.0	75.0	98500	1992	40
APC	CSTEEL STACK	6.0	100.0	127000	1992	40
APC	CSTEEL STACK	8.0	100.0	155000	1992	40
APC	CSTEEL STACK	10.0	100.0	170500	1992	40
APC	CCONCR STACK	8.0	100.0	425000	1992	40
APC	CCONCR STACK	10.0	100.0	453000	1992	40
BOILER	FTBOILER	20.0	0.0	600000	1991	25
BOILER	FTBOILER	60.0	0.0	1100000	1991	25
BOILER	FTBOILER	120.0	0.0	1700000	1991	25
BOILER	FTBOILER	160.0	0.0	2000000	1991	25
BOILER	FTBOILER	200.0	0.0	2300000	1991	25
BOILER	WTBOILER	60.0	0.0	1100000	1991	40
BOILER	WTBOILER	160.0	0.0	2000000	1991	40
BOILER	WTBOILER	200.0	0.0	2300000	1991	40
BOILER	RELVALVE	1.0	600.0	1900	1991	20
BOILER	RELVALVE	1.5	150.0	1700	1991	20
BOILER	RELVALVE	1.5	300.0	1800	1991	20
BOILER	RELVALVE	1.5	600.0	2000	1991	20
BOILER	RELVALVE	2.0	150.0	2400	1991	20
BOILER	RELVALVE	2.0	100.0	1900	1991	20
BOILER	RELVALVE	2.0	300.0	2600	1991	20
BOILER	RELVALVE	2.0	600.0	2700	1991	20
BOILER	WTBOILER	20.0	0.0	600000	1991	40
BOILER	WTBOILER	120.0	0.0	1700000	1991	40
BOILER	RELVALVE	2.5	150.0	2600	1991	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
BOILER	RELVALVE	2.5	300.0	2800	1991	20
BOILER	RELVALVE	2.5	600.0	3400	1991	20
BOILER	RELVALVE	3.0	150.0	3400	1991	20
BOILER	RELVALVE	3.0	300.0	3700	1991	20
BOILER	FW REG	1.5	150.0	600	1991	40
BOILER	FW REG	1.5	300.0	800	1991	40
BOILER	FW REG	1.5	600.0	1200	1991	40
BOILER	FW REG	2.0	150.0	600	1991	40
BOILER	FW REG	2.0	300.0	900	1991	40
BOILER	FW REG	2.0	600.0	1400	1991	40
BOILER	FW REG	2.5	150.0	800	1991	40
BOILER	FW REG	2.5	300.0	1200	1991	40
BOILER	FW REG	2.5	600.0	1800	1991	40
BOILER	FW REG	3.0	150.0	900	1991	40
BOILER	FW REG	3.0	300.0	1300	1991	40
BOILER	FW REG	3.0	600.0	2000	1991	40
BOILER	FW REG	4.0	150.0	1000	1991	40
BOILER	FW REG	4.0	300.0	1500	1991	40
BOILER	FW REG	4.0	600.0	2300	1991	40
BOILER	F FAN	10.0	0.0	7000	1991	40
BOILER	F FAN	50.0	0.0	20000	1991	40
BOILER	F FAN	100.0	0.0	30000	1991	40
BOILER	F FAN	150.0	0.0	40000	1991	40
BOILER	F FAN	200.0	0.0	50000	1991	40
BOILER	I FAN	10.0	0.0	7000	1991	40
BOILER	I FAN	50.0	0.0	20000	1991	40
BOILER	I FAN	100.0	0.0	30000	1991	40
BOILER	I FAN	150.0	0.0	40000	1991	40
BOILER	I FAN	200.0	0.0	50000	1991	40
BOILER	ECONOMIZER	20.0	0.0	36000	1992	20
BOILER	ECONOMIZER	60.0	0.0	73000	1992	20
BOILER	ECONOMIZER	120.0	0.0	104000	1992	20
BOILER	ECONOMIZER	160.0	0.0	125000	1992	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
BOILER	ECONOMIZER	200.0	0.0	146000	1992	20
BOILER	AIRHEAT	20.0	0.0	26000	1992	20
BOILER	AIRHEAT	60.0	0.0	52000	1992	20
BOILER	AIRHEAT	120.0	0.0	73000	1992	20
BOILER	AIRHEAT	160.0	0.0	94000	1992	20
BOILER	AIRHEAT	200.0	0.0	104000	1992	20
BOILER	AIRPHEAT	20.0	0.0	4000	1992	20
BOILER	AIRPHEAT	60.0	0.0	7000	1992	20
BOILER	AIRPHEAT	120.0	0.0	11000	1992	20
BOILER	AIRPHEAT	160.0	0.0	14000	1992	20
BOILER	AIRPHEAT	200.0	0.0	16000	1992	20
BOILER	DRUMCTL	0.0	0.0	5000	1991	20
BOILER	WTBURNER	25.0	0.0	50000	1991	40
BOILER	WTBURNER	75.0	0.0	100000	1991	40
BOILER	WTBURNER	150.0	0.0	150000	1991	40
BOILER	WTBURNER	200.0	0.0	175000	1991	40
BOILER	WTBURNER	250.0	0.0	200000	1991	40
BOILER	FTBURNER	25.0	0.0	50000	1991	25
BOILER	FTBURNER	75.0	0.0	100000	1991	25
BOILER	FTBURNER	150.0	0.0	150000	1991	25
BOILER	FTBURNER	200.0	0.0	175000	1991	25
BOILER	FTBURNER	250.0	0.0	200000	1991	25
BOILER	COAL BOILER	25.0	1.0	915000	1992	40
BOILER	COAL BOILER	75.0	1.0	1653000	1992	40
BOILER	COAL BOILER	150.0	1.0	2521000	1992	40
BOILER	COAL BOILER	200.0	1.0	3039000	1992	40
BOILER	COAL BOILER	250.0	1.0	3541000	1992	40
BOILER	COAL BOILER	25.0	2.0	875000	1992	40
BOILER	COAL BOILER	75.0	2.0	1586000	1992	40
BOILER	COAL BOILER	150.0	2.0	2454000	1992	40
BOILER	COAL BOILER	200.0	2.0	2939000	1992	40
BOILER	COAL BOILER	25.0	3.0	895000	1992	40
BOILER	COAL BOILER	75.0	3.0	1620000	1992	40

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
BOILER	COAL BOILER	25.0	4.0	814000	1992	40
BOILER	COAL BOILER	75.0	4.0	1519000	1992	40
BOILER	COAL BOILER	150.0	4.0	2387000	1992	40
BOILER	COAL BOILER	25.0	5.0	902000	1992	40
BOILER	COAL BOILER	75.0	5.0	1620000	1992	40
BOILER	COAL BOILER	150.0	5.0	2488000	1992	40
BOILER	COAL BOILER	25.0	6.0	902000	1992	40
BOILER	COAL BOILER	75.0	6.0	1620000	1992	40
BOILER	COAL BOILER	150.0	6.0	2488000	1992	40
BOILER	OVRFIRE-FAN	2000.0	0.0	5500	1992	40
BOILER	OVRFIRE-FAN	5000.0	0.0	8700	1992	40
BOILER	OVRFIRE-FAN	10000.0	0.0	16500	1992	40
BOILER	OVRFIRE-FAN	14000.0	0.0	23300	1992	40
BOILER	OVRFIRE-FAN	17000.0	0.0	26500	1992	40
BOILER	OVRFIRE-PIPE	8.0	0.0	52	1992	40
BOILER	OVRFIRE-PIPE	16.0	0.0	108	1992	40
BOILER	OVRFIRE-PIPE	24.0	0.0	197	1992	40
BOILER	OVRFIRE-PIPE	28.0	0.0	249	1992	40
BOILER	OVRFIRE-DAMP	8.0	0.0	465	1992	40
BOILER	OVRFIRE-DAMP	16.0	0.0	1556	1992	40
BOILER	OVRFIRE-DAMP	24.0	0.0	3180	1992	40
BOILER	OVRFIRE-DAMP	28.0	0.0	3880	1992	40
BOILER	FLYASH-HEADR	8.0	0.0	57	1992	40
BOILER	FLYASH-HEADR	16.0	0.0	112	1992	40
BOILER	FLYASH-HEADR	24.0	0.0	191	1992	40
BOILER	FLYASH-HEADR	28.0	0.0	219	1992	40
BOILER	FLYASH-APIP	2.0	0.0	13	1992	40
BOILER	FLYASH-APIP	3.0	0.0	18	1992	40
BOILER	FLYASH-APIP	4.0	0.0	22	1992	40
BOILER	FLYASH-DAMP	8.0	0.0	465	1992	40
BOILER	FLYASH-DAMP	16.0	0.0	1560	1992	40
BOILER	FLYASH-DAMP	24.0	0.0	3180	1992	40
BOILER	FLYASH-DAMP	28.0	0.0	3880	1992	40

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
BOILER	FLYASH-DSTV	2.0	0.0	86	1992	40
BOILER	FLYASH-DSTV	3.0	0.0	138	1992	40
BOILER	FLYASH-DSTV	4.0	0.0	187	1992	40
BOILER	FLYASH-ROTFD	4.0	0.0	19800	1992	40
BOILER	FLYASH-ROTFD	6.0	0.0	23100	1992	40
BOILER	FLYASH-ROTFD	8.0	0.0	26500	1992	40
BOILER	ISOL-DAMP-B	4.0	0.0	3600	1992	40
BOILER	ISOL-DAMP-B	9.0	0.0	4600	1992	40
BOILER	ISOL-DAMP-B	16.0	0.0	6030	1992	40
BOILER	ISOL-DAMP-B	25.0	0.0	7840	1992	40
BOILER	ISOL-DAMP-B	36.0	0.0	10060	1992	40
BOILER	ISOL-DAMP-L	4.0	0.0	3875	1992	40
BOILER	ISOL-DAMP-L	9.0	0.0	5250	1992	40
BOILER	ISOL-DAMP-L	16.0	0.0	7100	1992	40
BOILER	ISOL-DAMP-L	25.0	0.0	9500	1992	40
BOILER	ISOL-DAMP-L	36.0	0.0	12500	1992	40
BOILER	ISOL-DAMP-G	4.0	0.0	5500	1992	40
BOILER	ISOL-DAMP-G	9.0	0.0	8850	1992	40
BOILER	ISOL-DAMP-G	16.0	0.0	13500	1992	40
BOILER	ISOL-DAMP-G	25.0	0.0	19600	1992	40
BOILER	ISOL-DAMP-G	36.0	0.0	27000	1992	40
BOILER	EXPAN-JOINT	4.0	0.0	1550	1992	40
BOILER	EXPAN-JOINT	9.0	0.0	2050	1992	40
BOILER	EXPAN-JOINT	16.0	0.0	2500	1992	40
BOILER	EXPAN-JOINT	25.0	0.0	3000	1992	40
BOILER	EXPAN-JOINT	36.0	0.0	3300	1992	40
BOILER	STBLWR-STAND	10.0	0.0	13100	1992	40
BOILER	STBLWR-STAND	15.0	0.0	14100	1992	40
BOILER	STBLWR-STAND	20.0	0.0	15200	1992	40
BOILER	STBLWR-HVDTY	10.0	0.0	19900	1992	40
BOILER	STBLWR-HVDTY	15.0	0.0	20700	1992	40
BOILER	STBLWR-HVDTY	20.0	0.0	21400	1992	40
BOILER	STBLWR-CRL-F	0.0	0.0	16400	1992	40

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
BOILER	STBLWR-CRL-V	0.0	0.0	25300	1992	40
BOILER	STBLWR-CRL-V	0.0	0.0	25300	1992	40
BOILER	COAL BOILER	25.0	3.0	895000	1992	40
BOILER	COAL BOILER	75.0	3.0	1620000	1992	40
BOILER	COAL BOILER	25.0	4.0	814000	1992	40
BOILER	COAL BOILER	75.0	4.0	1519000	1992	40
BOILER	COAL BOILER	150.0	4.0	2387000	1992	40
BOILER	COAL BOILER	25.0	2.0	875000	1992	40
BOILER	COAL BOILER	75.0	2.0	1586000	1992	40
BOILER	COAL BOILER	150.0	2.0	2454000	1992	40
BOILER	COAL BOILER	200.0	2.0	2939000	1992	40
BOILER	COAL BOILER	25.0	7.0	1171000	1992	40
BOILER	COAL BOILER	75.0	7.0	1922000	1992	40
BOILER	COAL BOILER	150.0	7.0	2757000	1992	40
BOILER	COAL BOILER	25.0	5.0	902000	1992	40
BOILER	COAL BOILER	75.0	5.0	1620000	1992	40
BOILER	COAL BOILER	150.0	5.0	2488000	1992	40
BOILER	COAL BOILER	25.0	6.0	902000	1992	40
BOILER	COAL BOILER	75.0	6.0	1620000	1992	40
BOILER	COAL BOILER	150.0	6.0	2488000	1992	40
BOILER	COAL BOILER	25.0	8.0	848000	1992	40
BOILER	COAL BOILER	25.0	9.0	902000	1992	40
BOILER	COAL BOILER	75.0	9.0	1620000	1992	40
BOILER	COAL BOILER	150.0	9.0	2421000	1992	40
BOILER	COAL BOILER	200.0	9.0	2072000	1992	40
BOILER	COAL BOILER	250.0	9.0	3373000	1992	40
CALCULATE	INDEXEQUIP	325.3	0.0	0	1985	0
CALCULATE	INDEXEQUIP	318.4	0.0	0	1986	0
CALCULATE	INDEXEQUIP	323.8	0.0	0	1987	0
CALCULATE	INDEXEQUIP	342.5	0.0	0	1988	0
CALCULATE	INDEXEQUIP	355.4	0.0	0	1989	0
CALCULATE	INDEXEQUIP	357.6	0.0	0	1990	0
CALCULATE	INDEXEQUIP	370.0	0.0	0	1991	0

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
CALCULATE	INDEXOM	789.6	0.0	0	1985	0
CALCULATE	INDEXOM	797.6	0.0	0	1986	0
CALCULATE	INDEXOM	813.6	0.0	0	1987	0
CALCULATE	INDEXOM	852.0	0.0	0	1988	0
CALCULATE	INDEXOM	895.1	0.0	0	1989	0
CALCULATE	INDEXOM	915.1	0.0	0	1990	0
CALCULATE	RATEDISC	4.7	0.0	0	0	0
CALCULATE	BOILER	30.0	30.0	0	0	0
CALCULATE	FEEDWATER	4.0	4.0	0	0	0
CALCULATE	FUEL	9.0	9.0	0	0	0
CALCULATE	HEATRECOV	1.0	1.0	0	0	0
CALCULATE	APC	10.0	10.0	0	0	0
CALCULATE	COMBCTRL	11.0	11.0	0	0	0
CALCULATE	CHEMFEED	1.0	1.0	0	0	0
CALCULATE	MAKEUP	2.0	2.0	0	0	0
CALCULATE	CONDENSATE	2.0	2.0	0	0	0
CALCULATE	COMPAIR	5.0	5.0	0	0	0
CALCULATE	ELECTRIC	15.0	15.0	0	0	0
CALCULATE	PLANT	10.0	10.0	0	0	0
CHEMFEED	TANKPOLY	0.0	0.0	200	1991	20
CHEMFEED	TANKSTEEL	0.0	0.0	500	1991	20
CHEMFEED	TANKMIXER	0.0	0.0	1000	1991	20
CHEMFEED	PUMPSIMPLEX	0.0	0.0	3000	1991	20
CHEMFEED	PUMPDUPLEX	0.0	0.0	4000	1991	20
COAL HANDL	RAIL HOPPER	0.0	0.0	40000	1992	40
COAL HANDL	TRK HOPP VAL	24.0	0.0	14000	1992	20
COAL HANDL	TRK HOPP VAL	30.0	0.0	17000	1992	20
COAL HANDL	CARHOE	1.0	0.0	38800	1992	20
COAL HANDL	CARHOE	2.0	0.0	52700	1992	20
COAL HANDL	CAR PULLER	5.0	0.0	11650	1992	20
COAL HANDL	CAR PULLER	10.0	0.0	16400	1992	20
COAL HANDL	VOL VIB FDR	50.0	0.0	42000	1992	30
COAL HANDL	VOL VIB FDR	70.0	0.0	51500	1992	30

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
COAL HANDL	VOL VIB FDR	130.0	0.0	75000	1992	30
COAL HANDL	VOL VIB FDR	180.0	0.0	91000	1992	30
COAL HANDL	VOL VIB FDR	270.0	0.0	116000	1992	30
COAL HANDL	FRZN C CRSHR	15.0	0.0	30000	1992	40
COAL HANDL	FRZN C CRSHR	50.0	0.0	32500	1992	40
COAL HANDL	CSTRGE DRAIN	0.0	0.0	3	1992	40
COAL HANDL	CSTRGE PAVED	0.0	0.0	11	1992	40
COAL HANDL	CSTRGE WALL	0.0	0.0	8	1992	40
COAL HANDL	SILO CONCRT	0.0	0.0	246500	1992	40
COAL HANDL	SILO STEEL	0.0	0.0	167000	1992	40
COAL HANDL	BLTCONV CHNL	18.0	100.0	45700	1992	30
COAL HANDL	BLTCONV CHNL	18.0	150.0	58000	1992	30
COAL HANDL	BLTCONV CHNL	24.0	100.0	55200	1992	30
COAL HANDL	BLTCONV CHNL	24.0	150.0	68000	1992	30
COAL HANDL	BLTCONV TRUS	18.0	100.0	66000	1992	30
COAL HANDL	BLTCONV TRUS	18.0	150.0	83400	1992	30
COAL HANDL	BLTCONV TRUS	24.0	100.0	74700	1992	30
COAL HANDL	BLTCONV TRUS	24.0	150.0	98600	1992	30
COAL HANDL	SCREW CONV	9.0	20.0	6000	1992	20
COAL HANDL	SCREW CONV	12.0	20.0	7300	1992	20
COAL HANDL	SCREW CONV	14.0	20.0	8500	1992	20
COAL HANDL	SCREW CONV	16.0	20.0	9500	1992	20
COAL HANDL	ENMAS CONV L	64.0	50.0	56450	1992	20
COAL HANDL	ENMAS CONV L	64.0	100.0	73920	1992	20
COAL HANDL	ENMAS CONV L	228.0	50.0	91390	1992	20
COAL HANDL	ENMAS CONV L	228.0	100.0	134400	1992	20
COAL HANDL	ENMAS CONV C	52.0	100.0	118300	1992	20
COAL HANDL	ENMAS CONV C	52.0	200.0	161280	1992	20
COAL HANDL	ENMAS CONV C	125.0	100.0	165300	1992	20
COAL HANDL	ENMAS CONV C	125.0	200.0	223100	1992	20
COAL HANDL	ENMAS CONV H	97.0	50.0	62500	1992	20
COAL HANDL	ENMAS CONV H	97.0	100.0	85800	1992	20
COAL HANDL	ENMAS CONV H	178.0	100.0	91800	1992	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
COAL HANDL	ENMAS CONV H	178.0	150.0	116500	1992	20
COAL HANDL	BUCKET ELEV	5.0	0.0	50500	1992	20
COAL HANDL	BUCKET ELEV	15.0	0.0	79600	1992	20
COAL HANDL	BUCKET ELEV	25.0	0.0	94200	1992	20
COAL HANDL	BUCKET ELEV	50.0	0.0	152500	1992	20
COAL HANDL	DENSE CONV	24.0	0.0	130600	1992	20
COAL HANDL	DENSE CONV	64.0	0.0	148350	1992	20
COAL HANDL	DENSE CONV	80.0	0.0	161700	1992	20
COAL HANDL	MAGN SEP SCL	0.0	0.0	21100	1992	40
COAL HANDL	MAGN SEP MCL	0.0	0.0	14150	1992	40
COAL HANDL	METAL DET	0.0	0.0	13100	1992	40
COAL HANDL	BLT C SCALE	0.0	0.0	19000	1992	30
COAL HANDL	BLD DIV VAL	18.0	0.0	14000	1992	20
COAL HANDL	BLD DIV VAL	20.0	0.0	15000	1992	20
COAL HANDL	BLD DIV VAL	24.0	0.0	17000	1992	20
COAL HANDL	CHUTE CARBON	0.0	0.0	7700	1992	20
COAL HANDL	CHUTE STAINL	0.0	0.0	10200	1992	20
COAL HANDL	VOL BLT FDR	0.0	0.0	42000	1992	30
COAL HANDL	GRAV BLT FDR	0.0	0.0	86000	1992	30
COAL HANDL	GRAVBACH FDR	1.0	0.0	32400	1992	30
COAL HANDL	GRAVBACH FDR	2.0	0.0	32400	1992	30
COAL HANDL	GRAVBACH FDR	3.0	0.0	32400	1992	30
COAL HANDL	GRAVBACH FDR	6.0	0.0	34000	1992	30
COAL HANDL	GRAVBACH FDR	8.0	0.0	35000	1992	30
COAL HANDL	GRAVBACH FDR	10.0	0.0	36400	1992	30
COAL HANDL	BINS	25.0	0.0	21000	1992	40
COAL HANDL	BINS	75.0	0.0	37000	1992	40
COAL HANDL	BINS	150.0	0.0	61000	1992	40
COAL HANDL	BINS	200.0	0.0	65000	1992	40
COAL HANDL	BINS	250.0	0.0	83000	1992	40
COAL HANDL	BUNKER	75.0	0.0	54000	1992	40
COAL HANDL	BUNKER	225.0	0.0	122000	1992	40
COAL HANDL	BUNKER	450.0	0.0	163000	1992	40

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
COAL HANDL	BUNKER	600.0	0.0	179000	1992	40
COAL HANDL	BUNKER	750.0	0.0	211000	1992	40
COAL HANDL	PIPING	6.0	0.0	20	1992	40
COAL HANDL	PIPING	8.0	0.0	26	1992	40
COAL HANDL	PIPING	10.0	0.0	38	1992	40
COAL HANDL	PIPING	12.0	0.0	46	1992	40
COAL HANDL	PIPING	16.0	0.0	75	1992	40
COAL HANDL	PIPING	20.0	0.0	116	1992	40
COAL HANDL	PIPING	24.0	0.0	149	1992	40
COAL HANDL	COAL VALVE	12.0	0.0	4300	1992	40
COAL HANDL	COAL VALVE	16.0	0.0	4900	1992	40
COAL HANDL	COAL VALVE	20.0	0.0	5800	1992	40
COAL HANDL	COAL VALVE	24.0	0.0	7400	1992	40
COAL HANDL	VALVE OPER	0.0	0.0	5000	1992	40
COAL HANDL	AIR CANNON	600.0	0.0	2500	1992	40
COAL HANDL	AIR CANNON	700.0	0.0	2800	1992	40
COAL HANDL	AIR CANNON	800.0	0.0	3200	1992	40
COAL HANDL	AIR CANNON	900.0	0.0	3800	1992	40
COAL HANDL	AIR CANNON	1200.0	0.0	5200	1992	40
COAL HANDL	AIR CANNON	1800.0	0.0	6500	1992	40
COAL HANDL	BLT TRIPPER	5.0	0.0	33600	1992	30
COAL HANDL	NONSEG DISTR	2.0	0.0	12300	1992	30
COAL HANDL	NONSEG DISTR	3.0	0.0	14500	1992	30
COAL HANDL	NONSEG DISTR	4.0	0.0	20000	1992	30
COMBCTRL	PLANTMASTER	0.0	0.0	5000	1992	30
COMBCTRL	BOILMASTER	0.0	0.0	5000	1992	30
COMBCTRL	O2TRIM	0.0	0.0	10000	1992	30
COMBCTRL	FLAMESAFE	0.0	0.0	10000	1992	30
COMBCTRL	PSIGSENSOR	0.0	0.0	1100	1992	30
COMBCTRL	PSIGCTRL	0.0	0.0	2600	1992	30
COMBCTRL	DAMPACT	0.0	0.0	1100	1992	30
COMBCTRL	FLOWMETER	0.0	0.0	3100	1992	30
COMBCTRL	TEMPREC	0.0	0.0	3100	1992	30

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
COMPAIR	AIRCOMPRECIP	50.0	0.0	20000	1991	20
COMPAIR	AIRCOMPRECIP	100.0	0.0	26000	1991	20
COMPAIR	AIRCOMPRECIP	150.0	0.0	32000	1991	20
COMPAIR	AIRCOMPRECIP	200.0	0.0	39000	1991	20
COMPAIR	AIRCOMPRECIP	350.0	0.0	48000	1991	20
COMPAIR	AIRCOMPRECIP	750.0	0.0	96000	1991	20
COMPAIR	AIRCOMPCENTR	50.0	0.0	20000	1991	30
COMPAIR	AIRCOMPCENTR	100.0	0.0	26000	1991	30
COMPAIR	AIRCOMPCENTR	150.0	0.0	32000	1991	30
COMPAIR	AIRCOMPCENTR	200.0	0.0	39000	1991	30
COMPAIR	AIRCOMPCENTR	350.0	0.0	48000	1991	30
COMPAIR	AIRCOMPCENTR	750.0	0.0	96000	1991	30
COMPAIR	AIRDRYERDESC	50.0	0.0	12000	1991	20
COMPAIR	AIRDRYERDESC	100.0	0.0	13000	1991	20
COMPAIR	AIRDRYERDESC	150.0	0.0	16000	1991	20
COMPAIR	AIRDRYERDESC	200.0	0.0	18000	1991	20
COMPAIR	AIRDRYERDESC	250.0	0.0	20000	1991	20
COMPAIR	AIRDRYERREFR	50.0	0.0	12000	1991	15
COMPAIR	AIRDRYERREFR	100.0	0.0	13000	1991	15
COMPAIR	AIRDRYERREFR	150.0	0.0	16000	1991	15
COMPAIR	AIRDRYERREFR	200.0	0.0	18000	1991	15
COMPAIR	AIRDRYERREFR	250.0	0.0	20000	1991	15
COMPAIR	AIRRECV	100.0	0.0	600	1991	30
COMPAIR	AIRRECV	200.0	0.0	1100	1991	30
COMPAIR	AIRRECV	400.0	0.0	1900	1991	30
COMPAIR	AIRRECV	600.0	0.0	2500	1991	30
COMPAIR	AIRRECV	1000.0	0.0	3000	1991	30
CONDENSATE	OILREMOVAL	100.0	0.0	40000	1991	25
CONDENSATE	OILREMOVAL	400.0	0.0	90000	1991	25
CONDENSATE	OILREMOVAL	700.0	0.0	130000	1991	25
CONDENSATE	OILREMOVAL	1000.0	0.0	160000	1991	25
CONDENSATE	OILREMOVAL	1200.0	0.0	175000	1991	25
CONDENSATE	DEARTHFILTER	100.0	0.0	40000	1991	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
CONDENSATE	DEARTHFILTER	400.0	0.0	90000	1991	20
CONDENSATE	DEARTHFILTER	700.0	0.0	130000	1991	20
CONDENSATE	DEARTHFILTER	1000.0	0.0	160000	1991	20
CONDENSATE	DEARTHFILTER	1200.0	0.0	175000	1991	20
CONDENSATE	NAPOLISHERS	100.0	0.0	280000	1991	20
CONDENSATE	NAPOLISHERS	400.0	0.0	650000	1991	20
CONDENSATE	NAPOLISHERS	700.0	0.0	900000	1991	20
CONDENSATE	NAPOLISHERS	1000.0	0.0	1120000	1991	20
CONDENSATE	NAPOLISHERS	1200.0	0.0	1250000	1991	20
ELECTRIC	TRANSPCB	200.0	0.0	25000	1991	40
ELECTRIC	TRANSPCB	500.0	0.0	30000	1991	40
ELECTRIC	TRANSPCB	1000.0	0.0	35000	1991	40
ELECTRIC	TRANSPCB	2000.0	0.0	42000	1991	40
ELECTRIC	TRANSPCB	5000.0	0.0	60000	1991	40
ELECTRIC	TRANSFORMER	200.0	0.0	19000	1991	40
ELECTRIC	TRANSFORMER	500.0	0.0	25000	1991	40
ELECTRIC	TRANSFORMER	1000.0	0.0	32000	1991	40
ELECTRIC	TRANSFORMER	2000.0	0.0	44000	1991	40
ELECTRIC	TRANSFORMER	5000.0	0.0	80000	1991	40
ELECTRIC	SWITCH	400.0	0.0	12000	1991	40
ELECTRIC	SWITCH	1000.0	0.0	20000	1991	40
ELECTRIC	SWITCH	2000.0	0.0	25000	1991	40
ELECTRIC	SWITCH	4000.0	0.0	38000	1991	40
ELECTRIC	SWITCH	10000.0	0.0	66000	1991	40
ELECTRIC	MOTORCTRL	100.0	0.0	800	1991	40
ELECTRIC	MOTORCTRL	200.0	0.0	1400	1991	40
ELECTRIC	MOTORCTRL	500.0	0.0	2900	1991	40
ELECTRIC	MOTORCTRL	1000.0	0.0	5400	1991	40
ELECTRIC	MOTORCTRL	2000.0	0.0	12000	1991	40
ELECTRIC	MOTORSTARTER	10.0	0.0	1200	1991	40
ELECTRIC	MOTORSTARTER	25.0	0.0	1400	1991	40
ELECTRIC	MOTORSTARTER	50.0	0.0	2100	1991	40
ELECTRIC	MOTORSTARTER	100.0	0.0	3700	1991	40

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
ELECTRIC	MOTORSTARTER	200.0	0.0	7500	1991	40
ELECTRIC	EMERGENCYGEN	100.0	0.0	35000	1991	30
ELECTRIC	EMERGENCYGEN	500.0	0.0	87000	1991	30
ELECTRIC	EMERGENCYGEN	1000.0	0.0	138000	1991	30
ELECTRIC	EMERGENCYGEN	150.0	0.0	176000	1991	30
ELECTRIC	EMERGENCYGEN	2000.0	0.0	210000	1991	30
FEEDWATER	DAIRHEATER	50000.0	0.0	25000	1991	40
FEEDWATER	DAIRHEATER	400000.0	0.0	80000	1991	40
FEEDWATER	DAIRHEATER	600000.0	0.0	100000	1991	40
FEEDWATER	FWHEATER	100.0	0.0	17000	1991	40
FEEDWATER	FWHEATER	200.0	0.0	30000	1991	40
FEEDWATER	FWHEATER	500.0	0.0	50000	1991	40
FEEDWATER	FWHEATER	1000.0	0.0	79000	1991	40
FEEDWATER	FWHEATER	1200.0	0.0	85000	1991	40
FEEDWATER	FWHEATER	30000.0	0.0	40000	1991	25
FEEDWATER	DAIRHEATER	100000.0	0.0	35000	1991	40
FEEDWATER	DAIRHEATER	200000.0	0.0	55000	1991	40
FEEDWATER	FWHEATER	500.0	0.0	50000	1991	40
FEEDWATER	WATERSTOR	10000.0	0.0	25000	1991	25
FEEDWATER	WATERSTOR	20000.0	0.0	38000	1991	25
FEEDWATER	WATERSTOR	50000.0	0.0	66000	1991	25
FEEDWATER	WATERSTOR	75000.0	0.0	84000	1991	25
FEEDWATER	WATERSTOR	100000.0	0.0	100000	1991	25
FEEDWATER	TREATPUMP	1.0	0.0	3500	1991	20
FEEDWATER	TREATPUMP	3.0	0.0	4000	1991	20
FEEDWATER	TREATPUMP	5.0	0.0	4500	1991	20
FEEDWATER	TREATPUMP	10.0	0.0	5500	1991	20
FEEDWATER	TREATPUMP	20.0	0.0	7000	1991	20
FEEDWATER	CONDPUMP	1.0	0.0	3500	1991	20
FEEDWATER	CONDPUMP	3.0	0.0	4000	1991	20
FEEDWATER	CONDPUMP	5.0	0.0	4500	1991	20
FEEDWATER	CONDPUMP	10.0	0.0	5500	1991	20
FEEDWATER	CONDPUMP	20.0	0.0	7000	1991	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
FEEDWATER	CONDREC	100.0	0.0	6000	1991	30
FEEDWATER	CONDREC	500.0	0.0	14000	1991	30
FEEDWATER	CONDREC	1000.0	0.0	22000	1991	30
FEEDWATER	CONDREC	2500.0	0.0	37000	1991	30
FEEDWATER	CONDREC	5000.0	0.0	56000	1991	30
FEEDWATER	FEEDPUMP	10.0	0.0	14000	1991	30
FEEDWATER	FEEDPUMP	50.0	0.0	19000	1991	30
FEEDWATER	FEEDPUMP	100.0	0.0	24000	1991	30
FEEDWATER	FEEDPUMP	150.0	0.0	35000	1991	30
FEEDWATER	FEEDPUMP	200.0	0.0	37000	1991	30
FEEDWATER	MUPUMP	1.0	0.0	3500	1991	20
FEEDWATER	MUPUMP	3.0	0.0	4000	1991	20
FEEDWATER	MUPUMP	5.0	0.0	4500	1991	20
FEEDWATER	MUPUMP	10.0	0.0	5500	1991	20
FEEDWATER	MUPUMP	20.0	0.0	7000	1991	20
FEEDWATER	CIRCPUMP	10.0	0.0	14000	1991	30
FEEDWATER	CIRCPUMP	25.0	0.0	15000	1991	30
FEEDWATER	CIRCPUMP	50.0	0.0	19000	1991	30
FEEDWATER	CIRCPUMP	75.0	0.0	23000	1991	30
FEEDWATER	CIRCPUMP	100.0	0.0	24000	1991	30
FEEDWATER	SEDTANK	24.0	5.0	3000	1991	40
FEEDWATER	SEDTANK	36.0	6.0	5200	1991	40
FEEDWATER	SEDTANK	36.0	8.0	6200	1991	40
FEEDWATER	SEDTANK	42.0	10.0	8500	1991	40
FEEDWATER	SEDTANK	48.0	10.0	10000	1991	40
FEEDWATER	EXPTANK	36.0	10.0	7000	1991	40
FEEDWATER	EXPTANK	48.0	16.0	13000	1991	40
FEEDWATER	EXPTANK	60.0	20.0	19000	1991	40
FEEDWATER	EXPTANK	72.0	30.0	30000	1991	40
FEEDWATER	EXPTANK	96.0	40.0	50000	1991	40
FEEDWATER	FWPIPINGVAL	4.0	150.0	1100	1991	20
FEEDWATER	FWPIPINGVAL	4.0	300.0	1500	1991	20
FEEDWATER	FWPIPINGVAL	4.0	600.0	2900	1991	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
FEEDWATER	FWPIPINGVAL	6.0	150.0	1700	1991	20
FEEDWATER	FWPIPINGVAL	6.0	300.0	2500	1991	20
FEEDWATER	FWPIPINGVAL	6.0	600.0	2900	1991	20
FEEDWATER	FWPIPINGVAL	8.0	150.0	2600	1991	20
FEEDWATER	FWPIPINGVAL	8.0	300.0	3700	1991	20
FEEDWATER	FWPIPINGVAL	8.0	600.0	8200	1991	20
FEEDWATER	FWPIPINGVAL	10.0	150.0	3700	1991	20
FEEDWATER	FWPIPINGVAL	10.0	300.0	5600	1991	20
FEEDWATER	FWPIPINGVAL	10.0	600.0	12000	1991	20
FEEDWATER	FWPIPINGVAL	12.0	150.0	4800	1991	20
FEEDWATER	FWPIPINGVAL	12.0	300.0	7100	1991	20
FEEDWATER	FWPIPINGVAL	12.0	600.0	15200	1991	20
FEEDWATER	COOLPUMP	5.0	0.0	4500	1991	20
FEEDWATER	COOLPUMP	10.0	0.0	5500	1991	20
FEEDWATER	COOLPUMP	20.0	0.0	7000	1991	20
FEEDWATER	COOLPUMP	30.0	0.0	8200	1991	20
FEEDWATER	COOLPUMP	50.0	0.0	11400	1991	20
FEEDWATER	HTWPUMP	50.0	0.0	19000	1991	30
FEEDWATER	HTWPUMP	75.0	0.0	23000	1991	30
FEEDWATER	HTWPUMP	100.0	0.0	24000	1991	30
FEEDWATER	HTWPUMP	150.0	0.0	35000	1991	30
FEEDWATER	HTWPUMP	200.0	0.0	37000	1991	30
FEEDWATER	MUPUMP	50.0	0.0	11400	1991	20
FIRE PROT	H2OBOOSTPUMP	0.0	0.0	17500	1992	40
FIRE PROT	FIRE DEP CON	0.0	0.0	350	1992	40
FIRE PROT	AUTO SPRINK	0.0	0.0	40	1992	40
FIRE PROT	DELUGE VALVE	0.0	0.0	220	1992	40
FIRE PROT	3W-HYDRANT	0.0	0.0	1550	1992	40
FIRE PROT	FIRE HOSE	0.0	0.0	560	1992	40
FIRE PROT	AUTO ALARM	0.0	0.0	6000	1992	40
FIRE PROT	MAN PULL STN	0.0	0.0	145	1992	40
FIRE PROT	PORT EXTGSHR	0.0	0.0	155	1992	40
FIRE PROT	SMOKE DET	0.0	0.0	150	1992	40

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
FIRE PROT	CO DET	0.0	0.0	165	1992	40
FIRE PROT	METHANE DET	0.0	0.0	180	1992	40
FIRE PROT	SPOTHEAT DET	0.0	0.0	115	1992	40
FIRE PROT	LIN HEAT DET	0.0	0.0	100	1992	40
FIRE PROT	H2O-TANK	0.0	0.0	225000	1992	40
FIRE PROT	DRY SPRNKLR	0.0	0.0	2	1992	40
FIRE PROT	WET SPRNKLR	0.0	0.0	2	1992	40
FIRE PROT	DELUGE	0.0	0.0	4	1992	40
FIRE PROT	CO2/HALON	0.0	0.0	12	1992	40
FUEL	UNLOADPUMP	1.0	0.0	3600	1992	20
FUEL	UNLOADPUMP	5.0	0.0	4200	1992	20
FUEL	UNLOADPUMP	20.0	0.0	7300	1992	20
FUEL	UNLOADPUMP	50.0	0.0	9800	1992	20
FUEL	UNLOADPUMP	100.0	0.0	16600	1992	20
FUEL	TANKBELOW	10000.0	0.0	16000	1992	30
FUEL	TANKBELOW	20000.0	0.0	27000	1992	30
FUEL	TANKBELOW	30000.0	0.0	44000	1992	30
FUEL	TANKBELOW	40000.0	0.0	52000	1992	30
FUEL	TANKBELOW	50000.0	0.0	59000	1992	30
FUEL	PUMP	3.0	0.0	1000	1992	25
FUEL	PUMP	6.0	0.0	2000	1992	25
FUEL	PUMP	10.0	0.0	3000	1992	25
FUEL	PUMP	20.0	0.0	4000	1992	25
FUEL	PUMP	60.0	0.0	8000	1992	25
FUEL	HEATER	3.0	0.0	1000	1992	30
FUEL	HEATER	6.0	0.0	2000	1992	30
FUEL	HEATER	10.0	0.0	3000	1992	30
FUEL	HEATER	20.0	0.0	4000	1992	30
FUEL	HEATER	60.0	0.0	8000	1992	30
FUEL	OILPIPEABOVE	2.0	0.0	14	1992	50
FUEL	OILPIPEABOVE	3.0	0.0	21	1992	50
FUEL	OILPIPEABOVE	4.0	0.0	24	1992	50
FUEL	OILPIPEABOVE	6.0	0.0	41	1992	50

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
FUEL	OILPIPEABOVE	8.0	0.0	52	1992	50
FUEL	OILPIPEBELOW	2.0	0.0	26	1992	25
FUEL	OILPIPEBELOW	3.0	0.0	37	1992	25
FUEL	OILPIPEBELOW	4.0	0.0	51	1992	25
FUEL	OILPIPEBELOW	6.0	0.0	89	1992	25
FUEL	OILPIPEBELOW	8.0	0.0	217	1992	25
FUEL	NAGPIPEABOVE	2.0	0.0	14	1992	50
FUEL	NAGPIPEABOVE	3.0	0.0	19	1992	50
FUEL	NAGPIPEABOVE	4.0	0.0	24	1992	50
FUEL	NAGPIPEABOVE	6.0	0.0	42	1992	50
FUEL	NAGPIPEABOVE	8.0	0.0	56	1992	50
FUEL	NAGPIPEBELOW	2.0	0.0	14	1992	25
FUEL	NAGPIPEBELOW	3.0	0.0	19	1992	25
FUEL	NAGPIPEBELOW	4.0	0.0	24	1992	25
FUEL	NAGPIPEBELOW	6.0	0.0	42	1992	25
FUEL	NAGPIPEBELOW	8.0	0.0	56	1992	25
FUEL	TANKABOVE	100000.0	0.0	83000	1992	40
FUEL	TANKABOVE	200000.0	0.0	125000	1992	40
FUEL	TANKABOVE	500000.0	0.0	218000	1992	40
FUEL	TANKABOVE	800000.0	0.0	291000	1992	40
FUEL	TANKABOVE	1000000.0	0.0	333000	1992	40
HEATRECOV	FLASHTANK	1.0	2.0	300	1991	25
HEATRECOV	FLASHTANK	2.0	3.0	500	1991	25
HEATRECOV	FLASHTANK	3.0	4.0	1100	1991	25
HEATRECOV	FLASHTANK	4.0	6.0	2000	1991	25
HEATRECOV	HEATEXCH	5.0	0.0	1000	1991	30
HEATRECOV	HEATEXCH	20.0	0.0	1600	1991	30
HEATRECOV	HEATEXCH	50.0	0.0	2500	1991	30
HEATRECOV	HEATEXCH	100.0	0.0	4500	1991	30
HEATRECOV	HEATEXCH	200.0	0.0	8500	1991	30
MAKEUP	CHLORINATOR	50.0	0.0	6000	1991	20
MAKEUP	CHLORINATOR	250.0	0.0	15000	1991	20
MAKEUP	CHLORINATOR	500.0	0.0	23000	1991	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
MAKEUP	CHLORINATOR	750.0	0.0	30000	1991	20
MAKEUP	CHLORINATOR	1000.0	0.0	35000	1991	20
MAKEUP	FLOCCULATOR	50.0	0.0	7000	1991	30
MAKEUP	FLOCCULATOR	250.0	0.0	17000	1991	30
MAKEUP	FLOCCULATOR	500.0	0.0	25000	1991	30
MAKEUP	FLOCCULATOR	750.0	0.0	32000	1991	30
MAKEUP	FLOCCULATOR	1000.0	0.0	37000	1991	30
MAKEUP	CLARIFIER	50.0	0.0	72000	1991	30
MAKEUP	CLARIFIER	250.0	0.0	150000	1991	30
MAKEUP	CLARIFIER	500.0	0.0	190000	1991	30
MAKEUP	CLARIFIER	750.0	0.0	245000	1991	30
MAKEUP	CLARIFIER	1000.0	0.0	297000	1991	30
MAKEUP	FILTERGRAV	50.0	0.0	25000	1991	30
MAKEUP	FILTERGRAV	500.0	0.0	60000	1991	30
MAKEUP	FILTERGRAV	1000.0	0.0	79000	1991	30
MAKEUP	FILTERGRAV	1500.0	0.0	95000	1991	30
MAKEUP	FILTERGRAV	2000.0	0.0	128000	1991	30
MAKEUP	FILTERPRESS	50.0	0.0	10000	1991	20
MAKEUP	FILTERPRESS	150.0	0.0	15000	1991	20
MAKEUP	FILTERPRESS	250.0	0.0	21000	1991	20
MAKEUP	FILTERPRESS	350.0	0.0	25000	1991	20
MAKEUP	FILTERPRESS	500.0	0.0	31000	1991	20
MAKEUP	FILTERCARB	50.0	0.0	10000	1991	20
MAKEUP	FILTERCARB	150.0	0.0	15000	1991	20
MAKEUP	FILTERCARB	250.0	0.0	21000	1991	20
MAKEUP	FILTERCARB	350.0	0.0	25000	1991	20
MAKEUP	FILTERCARB	500.0	0.0	31000	1991	20
MAKEUP	SLUDGESOFT	50.0	0.0	190000	1991	30
MAKEUP	SLUDGESOFT	150.0	0.0	370000	1991	30
MAKEUP	SLUDGESOFT	300.0	0.0	560000	1991	30
MAKEUP	SLUDGESOFT	450.0	0.0	810000	1991	30
MAKEUP	SLUDGESOFT	600.0	0.0	1030000	1991	30
MAKEUP	HOTPROCSOFT	50.0	0.0	190000	1991	35

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
MAKEUP	HOTPROCSOFT	150.0	0.0	370000	1991	35
MAKEUP	HOTPROCSOFT	300.0	0.0	560000	1991	35
MAKEUP	HOTPROCSOFT	450.0	0.0	810000	1991	35
MAKEUP	HOTPROCSOFT	600.0	0.0	1030000	1991	35
MAKEUP	SZSOFT	50.0	0.0	70000	1991	20
MAKEUP	SZSOFT	150.0	0.0	135000	1991	20
MAKEUP	SZSOFT	300.0	0.0	205000	1991	20
MAKEUP	SZSOFT	450.0	0.0	260000	1991	20
MAKEUP	SZSOFT	600.0	0.0	310000	1991	20
MAKEUP	DEALKALK	50.0	0.0	70000	1991	20
MAKEUP	DEALKALK	150.0	0.0	135000	1991	20
MAKEUP	DEALKALK	300.0	0.0	205000	1991	20
MAKEUP	DEALKALK	450.0	0.0	260000	1991	20
MAKEUP	DEALKALK	600.0	0.0	310000	1991	20
MAKEUP	SPLITSOFT	50.0	0.0	190000	1991	20
MAKEUP	SPLITSOFT	250.0	0.0	505000	1991	20
MAKEUP	SPLITSOFT	500.0	0.0	865000	1991	20
MAKEUP	SPLITSOFT	750.0	0.0	1180000	1991	20
MAKEUP	SPLITSOFT	1000.0	0.0	1455000	1991	20
MAKEUP	REVOSMOSIS	50.0	0.0	250000	1991	25
MAKEUP	REVOSMOSIS	100.0	0.0	321000	1991	25
MAKEUP	REVOSMOSIS	150.0	0.0	610000	1991	25
MAKEUP	REVOSMOSIS	200.0	0.0	725000	1991	25
MAKEUP	REVOSMOSIS	250.0	0.0	830000	1991	25
MAKEUP	FORCDEGASS	50.0	0.0	10000	1991	25
MAKEUP	FORCDEGASS	250.0	0.0	15000	1991	25
MAKEUP	FORCDEGASS	500.0	0.0	20000	1991	25
MAKEUP	FORCDEGASS	750.0	0.0	25000	1991	25
MAKEUP	FORCDEGASS	1000.0	0.0	30000	1991	25
MAKEUP	DEMINERAL	50.0	0.0	450000	1991	20
MAKEUP	DEMINERAL	250.0	0.0	1200000	1991	20
MAKEUP	DEMINERAL	500.0	0.0	1800000	1991	20
MAKEUP	DEMINERAL	750.0	0.0	2300000	1991	20

SYSTEM	ITEM	SPEC1	SPEC2	COST	COSTYR	LIFESPAN
MAKEUP	DEMINERAL	1000.0	0.0	2700000	1991	20
MAKEUP	EVAPORATOR	50.0	0.0	10000	1991	30
MAKEUP	EVAPORATOR	250.0	0.0	30000	1991	30
MAKEUP	EVAPORATOR	500.0	0.0	55000	1991	30
MAKEUP	EVAPORATOR	750.0	0.0	70000	1991	30
MAKEUP	EVAPORATOR	1000.0	0.0	80000	1991	30
MAKEUP	VACUDEGASS	50.0	0.0	30000	1991	25
MAKEUP	VACUDEGASS	250.0	0.0	45000	1991	25
MAKEUP	VACUDEGASS	500.0	0.0	60000	1991	25
MAKEUP	VACUDEGASS	750.0	0.0	60000	1991	25
MAKEUP	VACUDEGASS	750.0	0.0	75000	1991	25
MAKEUP	VACUDEGASS	1000.0	0.0	90000	1991	25
PLANT	SUMPPUMPSUB	5.0	0.0	5400	1991	15
PLANT	SUMPPUMPSUB	10.0	0.0	5500	1991	15
PLANT	SUMPPUMPSUB	50.0	0.0	5600	1991	15
PLANT	SUMPPUMPVERT	5.0	0.0	4900	1991	15
PLANT	SUMPPUMPVERT	10.0	0.0	5000	1991	15
PLANT	SUMPPUMPVERT	50.0	0.0	5100	1991	15
PLANT	LIGHTS	0.0	0.0	20	1991	40
PLANT	CONCRETE	0.0	0.0	400	1991	75
PLANT	STEEL	0.0	0.0	3000	1991	75
PLANT	ROOF	0.0	0.0	7	1991	20
PLANT	SIDING	0.0	0.0	20	1991	20
PLANT	WINDOWS	0.0	0.0	41	1991	20
PLANT	DOORS	0.0	0.0	800	1991	20

Appendix D: Data in VALID.DBF

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
APC	COLLECTOR	cap(ACFM)		mspec1 > 0	empty(mspec2)
APC	BAGHOUSE	cap(ACFM)		mspec1 > 0	empty(mspec2)
APC	PRECIP	cap(ACFM)		mspec1 > 0	empty(mspec2)
APC	BREECH	size(sq ft)		mspec1 > 0	empty(mspec2)
APC	STACK	diameter(ft)	height(ft)	mspec1 > 0	mspec2 > 0
APC	OPACMONITOR			empty(mspec1)	empty(mspec2)
APC	SCRUBBER	cap(ACFM)		mspec1 > 0	empty(mspec2)
APC	ASHCONV	tons/hr		mspec1 > 0	empty(mspec2)
APC	ASHSTOR	tons		mspec1 > 0	empty(mspec2)
APC	CSTEEL STACK	diameter(ft)	height(ft)	mspec1 >= 3 mspec1 <= 10	mspec2 >= 50 mspec2 <= 100
APC	CCONCR STACK	diameter(ft)	height(ft)	mspec1 >= 8 mspec1 <= 10	mspec2 = 100
BOILER	FTBOILER	MBtu		mspec1 > 0	empty(mspec2)
BOILER	WTBOILER	MBtu		mspec1 > 0	empty(mspec2)
BOILER	RELVALVE	in	psi	mspec1 > 0	empty(mspec2)
BOILER	FW REG	in	psi	mspec1 > 0	empty(mspec2)
BOILER	FTBURNER	MBtu		mspec1 > 0	empty(mspec2)
BOILER	F FAN	HP		mspec1 > 0	empty(mspec2)
BOILER	I FAN	HP		mspec1 > 0	empty(mspec2)
BOILER	ECONOMIZER	MBtu		mspec1 > 0	empty(mspec2)
BOILER	AIRHEAT	MBtu		mspec1 > 0	empty(mspec2)
BOILER	AIRPHEAT	MBtu		mspec1 > 0	empty(mspec2)
BOILER	DRUMCTL			empty(mspec1)	empty(mspec2)
BOILER	WTBURNER	MBtu		mspec1 > 0	empty(mspec2)
BOILER	OVRFIRE-FAN	cfm		mspec1>=2000 mspec1<=17000	empty(mspec2)
BOILER	OVRFIRE-PIPE	diameter(in)		mspec1 >= 8 mspec1 <= 28	empty(mspec2)

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
BOILER	OVRFIRE-DAMP	size(in)		mspec1 >= 8 mspec1 <= 28	empty(mspec2)
BOILER	EXPAN-JOINT	area(sq ft)		mspec1 >= 4 mspec1 <= 36	empty(mspec2)
BOILER	FLYASH-APIP	diameter(in)		mspec1 >= 2 mspec1 <= 4	empty(mspec2)
BOILER	FLYASH-HEADR	diameter(in)		mspec1 >= 8 mspec1 <= 28	empty(mspec2)
BOILER	FLYASH-PIPE	diameter(in)		mspec1 >= 2 mspec1 <= 4	empty(mspec2)
BOILER	FLYASH-DAMP	size(in)		mspec1 >= 8 mspec1 <= 28	empty(mspec2)
BOILER	FLYASH-DUSTV	size(in)		mspec1 >= 2 mspec1 <= 4	empty(mspec2)
BOILER	FLYASH-ROTFD	size(in)		mspec1 >= 4 mspec1 <= 8	empty(mspec2)
BOILER	ISOL-DAMP-B	area(sq ft)		mspec1 >= 4 mspec1 <= 36	empty(mspec2)
BOILER	ISOL-DAMP-L	area(sq ft)		mspec1 >= 4 mspec1 <= 36	empty(mspec2)
BOILER	ISOL-DAMP-G	area(sq ft)		mspec1 >= 4 mspec1 <= 36	empty(mspec2)
BOILER	STBLWR-HVDTY	length (ft)		mspec1 >= 10 mspec1 <= 20	empty(mspec2)
BOILER	STBLWR-STAND	length (ft)		mspec1 >= 10 mspec1 <= 20	empty(mspec2)
BOILER	STBLWR-CRL-F			empty(mspec1)	empty(mspec2)
BOILER	STBLWR-CRL-V			empty(mspec1)	empty(mspec2)
BOILER	COAL BOILER	MBtu	type	mspec1 >= 25 mspec1 <= 250	mspec2 >= 1 mspec2 <= 9
CALCULATE	RATEDISC	%		mspec1 > 0	empty(mspec2)
CALCULATE	BOILER	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	FEEDWATER	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	FUEL	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	HEATRECOV	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	APC	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	COMBCTRL	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	CHEMFEED	scalars	% weight	mspec1 > 0	mspec2 > 0

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
CALCULATE	MAKEUP	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	CONDENSATE	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	COMPAIR	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	ELECTRIC	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	PLANT	scalars	% weight	mspec1 > 0	mspec2 > 0
CALCULATE	INDEXEQUIP	index		mspec1 > 0	empty(mspec2)
CALCULATE	INDEXOM	index		mspec1 > 0	empty(mspec2)
CALCULATE	RATEDISC	%		mspec1 > 0	empty(mspec2)
CHEMFEED	TANKPOLY			empty(mspec1)	empty(mspec2)
CHEMFEED	TANKSTEEL			empty(mspec1)	empty(mspec2)
CHEMFEED	TANKMIXER			empty(mspec1)	empty(mspec2)
CHEMFEED	PUMPSIMPLEX			empty(mspec1)	empty(mspec2)
CHEMFEED	PUMPDUPLEX			empty(mspec1)	empty(mspec2)
COAL HANDL	rail hopper			empty(mspec1)	empty(mspec2)
COAL HANDL	trk hopp val	size(in)		mspec1 >= 24 mspec1 <= 30	empty(mspec2)
COAL HANDL	carhoe	model #		mspec1 >= 1 mspec1 <= 2	empty(mspec2)
COAL HANDL	car puller	size(Hp)		mspec1 >= 5 mspec1 <= 10	empty(mspec2)
COAL HANDL	vol vib fdr	TPH		mspec1 >= 50 mspec1 <= 270	empty(mspec2)
COAL HANDL	frzn c crshr	Hp		mspec1 >= 15 mspec1 <= 50	empty(mspec2)
COAL HANDL	bucket elev	Hp		mspec1 >= 5 mspec1 <= 50	empty(mspec2)
COAL HANDL	dense conv	TPH		mspec1 >= 24 mspec1 <= 80	empty(mspec2)
COAL HANDL	bld div val	size(in)		mspec1 >= 18 mspec1 <= 24	empty(mspec2)
COAL HANDL	bins	tons		mspec1 >= 25 mspec1 <= 200	empty(mspec2)
COAL HANDL	bunker	tons		mspec1 >= 75 mspec1 <= 750	empty(mspec2)
COAL HANDL	piping	diameter(in)		mspec1 >= 6 mspec1 <= 24	empty(mspec2)

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
COAL HANDL	coal valve	size(in)		mspec1 >= 12 mspec1 <= 24	empty(mspec2)
COAL HANDL	bltconv chnl	width(in)	length(ft)	mspec1 >= 18 mspec1 <= 24	mspec2 >= 100 mspec2 <= 150
COAL HANDL	bltconv trus	width(in)	length(ft)	mspec1 >= 18 mspec1 <= 24	mspec2 >= 100 mspec2 <= 150
COAL HANDL	screw conv	scrw dia(in)	length(ft)	mspec1 >= 9 mspec1 <= 16	mspec2 = 20
COAL HANDL	enmas conv L	TPH	length(ft)	mspec1 >= 64 mspec1 <= 128	mspec2 >= 50 mspec2 <= 100
COAL HANDL	enmas conv C	TPH	length(ft)	mspec1 >= 52 mspec1 <= 125	mspec2 >= 100 mspec2 <= 200
COAL HANDL	enmas conv H	TPH	length(ft)	mspec1 >= 97 mspec1 <= 178	mspec2 >= 50 mspec2 <= 150
COAL HANDL	silo concrt			empty(mspec1)	empty(mspec2)
COAL HANDL	silo steel			empty(mspec1)	empty(mspec2)
COAL HANDL	magn sep scl			empty(mspec1)	empty(mspec2)
COAL HANDL	magn sep mcl			empty(mspec1)	empty(mspec2)
COAL HANDL	metal det			empty(mspec1)	empty(mspec2)
COAL HANDL	blt c scale			empty(mspec1)	empty(mspec2)
COAL HANDL	chute carbon			empty(mspec1)	empty(mspec2)
COAL HANDL	chute stainl			empty(mspec1)	empty(mspec2)
COAL HANDL	vlave oper			empty(mspec1)	empty(mspec2)
COAL HANDL	vol blt fdr			empty(mspec1)	empty(mspec2)
COAL HANDL	grav blt fdr			empty(mspec1)	empty(mspec2)
COAL HANDL	gravbach fdr			empty(mspec1)	empty(mspec2)
COAL HANDL	strge draind			empty(mspec1)	empty(mspec2)
COAL HANDL	strge paved			empty(mspec1)	empty(mspec2)
COAL HANDL	strge walled			empty(mspec1)	empty(mspec2)
COAL HANDL	air cannon	model #		mspec1 >= 600 mspec1 <= 1800	empty(mspec2)
COAL HANDL	blt tripper	Hp		mspec1 = 5	empty(mspec2)
COAL HANDL	nonseg distr	# of outlets		mspec1 >= 2 mspec1 <= 4	empty(mspec2)
COMBCTRL	PLANTMASTER			empty(mspec1)	empty(mspec2)
COMBCTRL	BOILMASTER			empty(mspec1)	empty(mspec2)

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
COMBCTRL	O2TRIM			empty(mspec1)	empty(mspec2)
COMBCTRL	FLAMESAFE			empty(mspec1)	empty(mspec2)
COMBCTRL	PSIGSENSOR			empty(mspec1)	empty(mspec2)
COMBCTRL	PSIGCTRL			empty(mspec1)	empty(mspec2)
COMBCTRL	DAMPACT			empty(mspec1)	empty(mspec2)
COMBCTRL	FLOWMETER			empty(mspec1)	empty(mspec2)
COMBCTRL	TEMPREC			empty(mspec1)	empty(mspec2)
COMPAIR	AIRCOMPRECIP	SCFM		mspec1 > 0	empty(mspec2)
COMPAIR	AIRDRYERDESC	SCFM		mspec1 > 0	empty(mspec2)
COMPAIR	AIRRECV	gal		mspec1 > 0	empty(mspec2)
COMPAIR	AIRCOMPCENTR	SCFM		mspec1 > 0	empty(mspec2)
COMPAIR	AIRDRYERREFR	SCFM		mspec1 > 0	empty(mspec2)
CONDENSATE	OILREMOVAL	gpm		mspec1 > 0	empty(mspec2)
CONDENSATE	DEARTHFILTER	gpm		mspec1 > 0	empty(mspec2)
CONDENSATE	NAPOLISHERS	gpm		mspec1 > 0	empty(mspec2)
ELECTRIC	TRANSFORMER	KVA		mspec1 > 0	empty(mspec2)
ELECTRIC	SWITCH	amps		mspec1 > 0	empty(mspec2)
ELECTRIC	MOTORCTRL	amps		mspec1 > 0	empty(mspec2)
ELECTRIC	MOTORSTARTER	HP		mspec1 > 0	empty(mspec2)
ELECTRIC	TRANSPCB	KVA		mspec1 > 0	empty(mspec2)
ELECTRIC	EMERGENCYGEN	KVA		mspec1 > 0	empty(mspec2)
FEEDWATER	DAIRHEATER	lb/hr		mspec1 > 0	empty(mspec2)
FEEDWATER	FWHEATER	gpm		mspec1 > 0	empty(mspec2)
FEEDWATER	WATERSTOR	gallons		mspec1 > 0	empty(mspec2)
FEEDWATER	TREATPUMP	HP		mspec1 > 0	empty(mspec2)
FEEDWATER	CONDPUMP	HP		mspec1 > 0	empty(mspec2)
FEEDWATER	CONDREC	gallons		mspec1 > 0	empty(mspec2)
FEEDWATER	FEEDPUMP	HP		mspec1 > 0	empty(mspec2)
FEEDWATER	MUPUMP	HP		mspec1 > 0	empty(mspec2)
FEEDWATER	CIRCPUMP	HP		mspec1 > 0	empty(mspec2)
FEEDWATER	SEDTANK	diameter(in)	length(feet)	mspec1 > 0	mspec2 > 4 mspec2 < 11
FEEDWATER	EXPTANK	diameter(in)	length(feet)	mspec1 > 0	mspec2 >9 mspec2 < 41

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
FEEDWATER	FWPIPINGVAL	diameter(in)	psi	mspec1 > 0	mspec2 > 0
FEEDWATER	COOLPUMP	HP		mspec1 > 0	empty(mspec2)
FEEDWATER	HTWPUMP	HP		mspec1 > 0	empty(mspec2)
FIRE PROT	H2Oboostpump			empty(mspec1)	empty(mspec2)
FIRE PROT	fire dep con			empty(mspec1)	empty(mspec2)
FIRE PROT	auto sprink			empty(mspec1)	empty(mspec2)
FIRE PROT	deluge valve			empty(mspec1)	empty(mspec2)
FIRE PROT	3w-hydrant			empty(mspec1)	empty(mspec2)
FIRE PROT	fire hose			empty(mspec1)	empty(mspec2)
FIRE PROT	auto alarm			empty(mspec1)	empty(mspec2)
FIRE PROT	man pull stn			empty(mspec1)	empty(mspec2)
FIRE PROT	port extgshr			empty(mspec1)	empty(mspec2)
FIRE PROT	smoke det			empty(mspec1)	empty(mspec2)
FIRE PROT	CO det			empty(mspec1)	empty(mspec2)
FIRE PROT	methane det			empty(mspec1)	empty(mspec2)
FIRE PROT	spotheat det			empty(mspec1)	empty(mspec2)
FIRE PROT	lin heat det			empty(mspec1)	empty(mspec2)
FIRE PROT	H2O-tank			empty(mspec1)	empty(mspec2)
FIRE PROT	dry sprinklr			empty(mspec1)	empty(mspec2)
FIRE PROT	wet sprinklr			empty(mspec1)	empty(mspec2)
FIRE PROT	deluge			empty(mspec1)	empty(mspec2)
FIRE PROT	CO2/halon			empty(mspec1)	empty(mspec2)
FUEL	UNLOADPUMP	HP		mspec1 > 0	empty(mspec2)
FUEL	TANKABOVE	gallons		mspec1 > 0	empty(mspec2)
FUEL	TANKBELOW	gallons		mspec1 > 0	empty(mspec2)
FUEL	PUMP	gpm		mspec1 > 0	empty(mspec2)
FUEL	HEATER	gpm		mspec1 > 0	empty(mspec2)
FUEL	OILPIPEABOVE	diameter(in)		mspec1 > 0	empty(mspec2)
FUEL	OILPIPEBELOW	diameter(in)		mspec1 > 0	empty(mspec2)
FUEL	NAGPIPEABOVE	diameter(in)		mspec1 > 0	empty(mspec2)
FUEL	NAGPIPEBELOW	diameter(in)		mspec1 > 0	empty(mspec2)
HEATRECOV	FLASHTANK	diameter(ft)	height(ft)	mspec1 > 0	mspec2 > 0
HEATRECOV	HEATEXCH	gpm		mspec1 > 0	empty(mspec2)

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
MAKEUP	CHLORINATOR	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	FLOCCULATOR	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	CLARIFIER	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	FILTERGRAV	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	FILTERPRESS	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	FILTERCARB	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	SLUDGESOFT	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	HOTPROCSOFT	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	SZSOFT	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	DEALKALK	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	SPLITSOFT	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	REVOSMOSIS	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	FORCDEGASS	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	VACUDEGASS	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	DEMINERAL	gpm		mspec1 > 0	empty(mspec2)
MAKEUP	EVAPORATOR	gpm		mspec1 > 0	empty(mspec2)
PLANT	CONCRETE			empty(mspec1)	empty(mspec2)
PLANT	STEEL			empty(mspec1)	empty(mspec2)
PLANT	ROOF			empty(mspec1)	empty(mspec2)
PLANT	SIDING			empty(mspec1)	empty(mspec2)
PLANT	WINDOWS			empty(mspec1)	empty(mspec2)
PLANT	DOORS			empty(mspec1)	empty(mspec2)
PLANT	SUMPPUMPSUB	gpm		mspec1 > 0	empty(mspec2)
PLANT	LIGHTS			empty(mspec1)	empty(mspec2)
PLANT	SUMPPUMPVERT	gpm		mspec1 > 0	empty(mspec2)
ANNUAL	MAINT LABOR				
ANNUAL	MAINT SUPPLY				
ANNUAL	MAINT SERV				
ANNUAL	MAINT UTIL				
SYSTEM	APC				
SYSTEM	BOILER				
SYSTEM	CALCULATE				
SYSTEM	CHEMFEED				

SYSTEM	ITEM	UNIT1	UNIT2	VAL MSPEC1	VAL MSPEC2
SYSTEM	COAL HANDL				
SYSTEM	COMBCTRL				
SYSTEM	COMPAIR				
SYSTEM	CONDENSATE				
SYSTEM	ELECTRIC				
SYSTEM	FEEDWATER				
SYSTEM	FUEL				
SYSTEM	HEATRECOV				
SYSTEM	MAKEUPSYSTEM	PLANT			

Appendix E: Data Collection Forms for Oil and Gas

BOILER EVALUATION PARTS LIST	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
A. Boiler (WT/FT)	____	____	____MBtu/hr		____
1. Boiler Pressure Parts and Setting	____	____	____psig	____temp	____
2. Relief Valve(s)	____	____	____inches	____psig	____
3. Feedwater Regulator(s)	____	____	____inches	____psig	____
4. Boiler Burners	____	____	____MBtu		____
5. Boiler Fans ID	____	____	____Hp		____
Fans FD	____	____	____Hp		____
6. Boiler Economizer	____	____	____MBtu		____
Air Heater	____	____	____MBtu		____
Air Preheater	____	____	____MBtu		____
7. Drum Level Control	____	____	____		
B. Fuel Handling System					
1. Fuel Oil Unloading Pump	____	____	____Hp		____
2. Fuel Oil Tank - Above Ground	____	____	____gal		____
3. Fuel Oil Tank - Underground	____	____	____gal		____
4. Fuel Oil Pump	____	____	____gpm		____
5. Fuel Oil Heater	____	____	____gpm		____
6. Fuel Oil Piping System (ABV/BLW)	____	____	____Dia (in)	____Length (ft)	____
7. Natural Gas Piping (ABV/BLW)	____	____	____Dia (in)	____Length (ft)	____
C. Feedwater System					
1. Deaerating Heater	____	____	____lb/hr		____
2. Feedwater Heater	____	____	____gpm		____
3. Treated Water Storage	____	____	____gal		____
4. Treated Water Storage Pumps	____	____	____Hp		____
5. Condensate Pumps	____	____	____Hp		____
6. Condensate Receiver	____	____	____gal		____
7. Boiler Feed Pump	____	____	____Hp		____
8. Make-up Pumps	____	____	____Hp		____
9. Boiler Circulating Water Pump	____	____	____Hp		____
10. Sediment Tank	____	____	____Dia (inches)	____Length (ft)	____
11. Expansion Tank	____	____	____Dia (inches)	____Length (ft)	____
12. Feedwater Piping System Valve	____	____	____Dia (inches)	____psig	____
13. Cooling Water Pumps	____	____	____Hp		____
14. HTW Distribution System Pumps	____	____	____Hp		____
D. Heat Recovery System					
1. Blowdown Flash Tank	____	____	____Dia(inches)	____Height (inches)	____
2. Blowdown Heat Exchanger	____	____	____gpm		____

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
E. Air Pollution Control Systems and Emission Monitoring					
1. Mechanical Collector	____	____	____ACFM		____
2. Baghouse	____	____	____ACFM		____
3. Electrostatic Precipitator	____	____	____ACFM		____
4. Breaching	____	____	____Sq. Ft.		____
5. Stack Steel	____	____	____Dia (ft)	____ Height(ft)	____
Concrete	____	____	____Dia (ft)	____ Height(ft)	____
6. Opacity Monitor	____	____	____		____
7. Sulfur Dioxide Scrubber	____	____	____ACFM		____
8. Ash Handling System	____	____	____TPH		____
Storage	____	____	____Tons		____
F. Combustion Controls					
1. Plant Master/Boiler Master	____	____	____		____
2. Flame Safeguard System	____	____	____		____
3. Furnace Draft Control (DAMPACT)	____	____	____		____
4. Additional Boiler	____	____	____O2TRIM, FLOWMETER, TEMP		____
Instrumentation/Indicators	____	____	____PSIG CONTROL/SENSOR		____
G. Chemical Feed System					
1. Chemical Storage Tanks	____	____	____gal		____
2. Chemical Pumps	____	____	____Hp		____
3. Internal Treatment Program	____	____	____		____
H. Make-up Water System					
1. Chlorinator	____	____	____gpm		____
2. Flocculator/settling Basin	____	____	____gpm		____
3. Clarifier	____	____	____gpm		____
4. Gravity Filter	____	____	____gpm		____
5. Pressure Filter	____	____	____gpm		____
6. Carbon Filter	____	____	____gpm		____
7. Sludge Contact Softener	____	____	____gpm		____
8. Hot Process Softener	____	____	____gpm		____
9. Sodium Zeolite Softener	____	____	____gpm		____
10. Dealkalizer	____	____	____gpm		____
11. Reverse Osmosis Unit	____	____	____gpm		____
12. Forced Draft Degassifier	____	____	____gpm		____
13. Vacuum Degassifier	____	____	____gpm		____

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
14. Demineralizer	______	____	________gpm		______
- Strong and Weak Acid Cation Units	______	____	________gpm		______
- Strong and Weak Base Anion Units	______	____	________gpm		______
- Mixed Bed Units	______	____	________gpm		______
- Neutralization Equipment	______	____	________gpm		______
15. Evaporator	______	____	________gpm		______
16. Hydrogen Zeolite/Sodium Zeolite Split Stream Softener	______	____	________gpm		______
I. Condensate Polishing					
1. Oil Removal Equipment	______	____	________gpm		______
2. Diatomaceous Earth Filter	______	____	________gpm		______
3. Sodium Cycle Polisher	______	____	________gpm		______
J. Compressed Air System					
1. Air Compressor (CENTR/RECIP)	______	____	________SCFM		______
2. Air Dryer (DESC/REFR)	______	____	________SCFM		______
3. Air Receiver	______	____	________gal		______
K. Electrical System					
1. Transformer/TransPCB	______	____	________KVA		______
2. Switchgear--Main Circuit Breaker	______	____	________amps		______
3. Motor Control Center/Starter	______	____	________amps		______
4. Emergency Generator	______	____	________KVA		______
L. Physical Plant					
1. Building Siding, Roofing, Windows	______	____	________		______
and Doors	______	____	________		______
2. Building Concrete and Building Steel	______	____	________		______
3. Sump Pump (SUB/VERT)	______	____	________gpm		______
4. Building Lighting	______	____	________		______
M. Fire Protection Systems					
1. Fire Water Booster Pump	______	____	________		______
2. Fire Department Connections	______	____	________		______
3. Automatic Sprinkler	______	____	________		______
4. Deluge Valves	______	____	________		______
5. Three-Way Dry Barrel Hydrants	______	____	________		______
6. Fire Hose and Rack	______	____	________		______
7. Automatic Alarms and Annunciators	______	____	________		______
8. Manual Pull Stations	______	____	________		______
9. Portable Fire Extinguishers	______	____	________		______

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
10. Smoke Detectors	____	____	____		____
11. Carbon Monoxide Detectors	____	____	____		____
12. Methane Detectors	____	____	____		____
13. Spot Heat Detectors	____	____	____		____
14. Linear Heat Detectors	____	____	____		____
15. Water Tank (400,000 gal)	____	____	____		____
A. Boiler (WT/FT)	____	____	____MBtu/hr	____Stoker Type	
1. Boiler Pressure Parts and Setting	____	____	____psig	____temp	____
2. Relief Valve(s)	____	____	____inches	____psig	____
3. Feedwater Regulator(s)	____	____	____inches	____psig	____
4. Boiler Burners	____	____	____MBtu		____
5. Boiler Fans ID	____	____	____Hp		____
Fans FD	____	____	____Hp		____
6. Boiler Economizer	____	____	____MBtu		____
Air Heater	____	____	____MBtu		____
Air Preheater	____	____	____MBtu		____
7. Drum Level Control	____	____	____		____
A. Boiler (WT/FT)	____	____	____MBtu/hr	____Stoker Type	
1. Boiler Pressure Parts and Setting	____	____	____psig	____temp	____
2. Relief Valve(s)	____	____	____inches	____psig	____
3. Feedwater Regulator(s)	____	____	____inches	____psig	____
4. Boiler Burners	____	____	____MBtu		____
5. Boiler Fans ID	____	____	____Hp		____
Fans FD	____	____	____Hp		____
6. Boiler Economizer	____	____	____MBtu		____
Air Heater	____	____	____MBtu		____
Air Preheater	____	____	____MBtu		____
7. Drum Level Control	____	____	____		____

NOTES:

Appendix F: Data Collection Forms for Coal

BOILER EVALUATION PARTS LIST	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
A. Boiler (Stoker Type)	______	____	________MBtu/hr	________Stoker Type	______
1. Boiler Pressure Parts and Setting	______	____	________psig	________temp	______
2. Relief Valve(s)	______	____	________inches	________psig	______
3. Feedwater Regulator(s)	______	____	________inches	________psig	______
4. Auxiliary Fuel Burners	______	____	________MBtu/hr		______
5. Stoker Grate	______	____	________Type		______
6. Boiler Fans ID	______	____	________Hp		______
Fans FD	______	____	________Hp		______
7. Boiler Economizer	______	____	________MBtu		______
Air Heater	______	____	________MBtu		______
Air Preheater	______	____	________MBtu		______
8. Isolation Dampers	______	____	________Sq. Ft	________Type(Butterfly)	______
9. Expansion Joints	______	____	________Sq. Ft		______
10. Sootblowers	______	____	________Ft	________Standard/Heavy	______
11. Drum Level Control	______	____	________		
B. Overfire Air System					
1. High Pressure Fan	______	____	________CFM		______
2. Piping	______	____	________Dia(inches)	________Ft	______
3. Damper	______	____	________Size(inches)		______
C. Flyash Reinjection System					
1. Air Piping System Headers	______	____	________Dia(inches)	________Ft	______
2. Ash Reinjection Piping	______	____	________Dia(inches)	________Ft	______
3. Dampers	______	____	________Size(inches)		______
4. Dust Valves	______	____	________Size(inches)		______
5. Rotary Feeders	______	____	________Size(inches)		______
D. Feedwater System					
1. Deaerating Heater	______	____	________lb/hr		______
2. Feedwater Heater	______	____	________gpm		______
3. Treated Water Storage	______	____	________gal		______
4. Treated Water Storage Pumps	______	____	________Hp		______
5. Condensate Pumps	______	____	________Hp		______
6. Condensate Receiver	______	____	________gal		______
7. Boiler Feed Pump	______	____	________Hp		______
8. Make-up Pumps	______	____	________Hp		______
9. Boiler Circulating Water Pump	______	____	________Hp		______
10. Sediment Tank	______	____	________Dia (inches)	________Length (ft)	______
11. Expansion Tank	______	____	________Dia (inches)	________Length (ft)	______

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
12. Feedwater Piping System Valve	____	____	____Dia (inches)	____psig	____
13. Cooling Water Pumps	____	____	____Hp		____
14. HTW Distribution System Pumps	____	____	____Hp		____
E. Fuel Handling System					
1. Rail Hoppers	____	____	____		____
2. Track Hopper Valves	____	____	____Size (inches)		____
3. Carhoe	____	____	____Model (I or II)		____
4. Coal Car Puller	____	____	____Hp		____
5. Volum. Vib. Feeder	____	____	____TPH		____
6. Frozen Coal Crusher	____	____	____Hp		____
7. Outdoor Coal Storage	____	____	____Type		____
8. Coal Silos	____	____	____Conc./Steel		____
9. Belt Conveyor (channel/truss)	____	____	____ inches	____ ft	____
10. Screw Conveyor	____	____	____ inches	____ ft	____
11. En Masse Conveyor (TPH)	____	____	____ inches	____ ft	____
12. Bucket Elevators	____	____	____ Hp		____
13. Dense Phase Conveyor	____	____	____ TPH		____
14. Magnetic Separator	____	____	____ Self/Man Cleaning		____
15. Tramp Metal Detector	____	____	____		____
16. Belt Coal Scales	____	____	____		____
17. Blade Diverter Valve	____	____	____ size(inches)		____
18. Coal Feeders	____	____	____Type	____ TPH	____
19. Coal Bins	____	____	____ Tons		____
20. Coal Piping	____	____	____ Dia (inches)	____ Ft	____
21. Coal Valve	____	____	____ Size (inches)		____
22. Air Cannons	____	____	____ Model No.		____
23. Coal Belt Tripper	____	____	____ Hp		____
24. Conical Nonsegrataing Distributor	____	____	____ # of Outlets		____
25. Fuel Oil Unloading Pump	____	____	____Hp		____
26. Fuel Oil Tank - Above Ground	____	____	____gal		____
27. Fuel Oil Tank - Below Ground	____	____	____gal		____
28. Fuel Oil Pump	____	____	____gpm		____
29. Fuel Oil Heater	____	____	____gpm		____
30. Fuel Oil Piping System (ABV/BLW)	____	____	____Dia (inches)		____
31. Natural Gas Piping System (ABV/BLW)	____	____	____Dia (inches)		____
F. Heat Recovery System					
1. Blowdown Flash Tank	____	____	____Dia(inches)	____ Height (inches)	____

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
2. Blowdown Heat Exchanger	____	___	______gpm		____
G. Air Pollution Control Systems and Emission Monitoring					
1. Mechanical Collector	____	___	______ACFM		____
2. Baghouse	____	___	______ACFM		____
3. Electrostatic Precipitator	____	___	______ACFM		____
4. Breaching	____	___	______Sq. Ft.		____
5. Stack Steel	____	___	______Dia (ft)	______Height(ft)	____
Concrete	____	___	______Dia (ft)	______Height(ft)	____
6. Opacity Monitor	____	___	______		____
7. Sulfur Dioxide Scrubber	____	___	______ACFM		____
8. Ash Handling System	____	___	______TPH		____
Storage	____	___	______Tons		____
H. Combustion Controls					
1. Plant Master/Boiler Master	____	___	______		____
2. Flame Safeguard System	____	___	______		____
3. Furnace Draft Control (DAMPACT)	____	___	______		____
4. Additional Boiler	____	___	______O2TRIM, FLOWMETER, TEMP		____
Instrumentation/Indicators	____	___	______PSIG CONTROL/SENSOR		____
I. Chemical Feed System					
1. Chemical Storage Tanks	____	___	______gal		____
2. Chemical Pumps	____	___	______Hp		____
3. Internal Treatment Program	____	___	______		____
J. Make-up Water System					
1. Chlorinator	____	___	______gpm		____
2. Flocculator/settling Basin	____	___	______gpm		____
3. Clarifier	____	___	______gpm		____
4. Gravity Filter	____	___	______gpm		____
5. Pressure Filter	____	___	______gpm		____
6. Carbon Filter	____	___	______gpm		____
7. Sludge Contact Softener	____	___	______gpm		____
8. Hot Process Softener	____	___	______gpm		____
9. Sodium Zeolite Softener	____	___	______gpm		____
10. Dealkalizer	____	___	______gpm		____
11. Reverse Osmosis Unit	____	___	______gpm		____
12. Forced Draft Degassifier	____	___	______gpm		____
13. Vacuum Degassifier	____	___	______gpm		____

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
14. Demineralizer	____	____	____ gpm		____
- Strong and Weak Acid Cation Units	____	____	____ gpm		____
- Strong and Weak Base Anion Units	____	____	____ gpm		____
- Mixed Bed Units	____	____	____ gpm		____
- Neutralization Equipment	____	____	____ gpm		____
15. Evaporator	____	____	____ gpm		____
16. Hydrogen Zeolite/Sodium Zeolite Split Stream Softener	____	____	____ gpm		____
K. Condensate Polishing					
1. Oil Removal Equipment	____	____	____ gpm		____
2. Diatomaceous Earth Filter	____	____	____ gpm		____
3. Sodium Cycle Polisher	____	____	____ gpm		____
L. Compressed Air System					
1. Air Compressor (CENTR/RECIP)	____	____	____ SCFM		____
2. Air Dryer (DESC/REFR)	____	____	____ SCFM		____
3. Air Receiver	____	____	____ gal		____
M. Electrical System					
1. Transformer/TransPCB	____	____	____ KVA		____
2. Switchgear--Main Circuit Breaker	____	____	____ amps		____
3. Motor Control Center/Starter	____	____	____ amps		____
4. Emergency Generator	____	____	____ KVA		____
N. Physical Plant					
1. Building Siding, Roofing, Windows	____	____	____		____
and Doors	____	____	____		____
2. Building Concrete and Building Steel	____	____	____		____
3. Sump Pump (SUB/VERT)	____	____	____ gpm		____
4. Building Lighting	____	____	____		____
O. Fire Protection Systems					
1. Fire Water Booster Pump	____	____	____		____
2. Fire Department Connections	____	____	____		____
3. Automatic Sprinkler	____	____	____		____
4. Deluge Valves	____	____	____		____
5. Three-Way Dry Barrel Hydrants	____	____	____		____
6. Fire Hose and Rack	____	____	____		____
7. Automatic Alarms and Annunciators	____	____	____		____
8. Manual Pull Stations	____	____	____		____
9. Portable Fire Extinguishers	____	____	____		____

	Year Installed	Units	Specification 1	Specification 2	Condition Good, Fair, Poor
10. Smoke Detectors	____	____	____		____
11. Carbon Monoxide Detectors	____	____	____		____
12. Methane Detectors	____	____	____		____
13. Spot Heat Detectors	____	____	____		____
14. Linear Heat Detectors	____	____	____		____
15. Water Tank (400,000 gal)	____	____	____		____
A. Boiler (Stoker Type)	____	____	____MBtu/hr	____Stoker Type	____
1. Boiler Pressure Parts and Setting	____	____	____psig	____temp	____
2. Relief Valve(s)	____	____	____inches	____psig	____
3. Feedwater Regulator(s)	____	____	____inches	____psig	____
4. Auxiliary Fuel Burners	____	____	____MBtu/hr		____
5. Stoker Grate	____	____	____Type		____
6. Boiler Fans ID	____	____	____Hp		____
Fans FD	____	____	____Hp		____
7. Boiler Economizer	____	____	____MBtu		____
Air Heater	____	____	____MBtu		____
Air Preheater	____	____	____MBtu		____
8. Isolation Dampers	____	____	____Sq. Ft	____Type(Butterfly)	____
9. Expansion Joints	____	____	____Sq. Ft		____
10. Sootblowers	____	____	____Ft	____Standard/Heavy	____
11. Drum Level Control	____	____	____		
A. Boiler (Stoker Type)	____	____	____MBtu/hr	____Stoker Type	____
1. Boiler Pressure Parts and Setting	____	____	____psig	____temp	____
2. Relief Valve(s)	____	____	____inches	____psig	____
3. Feedwater Regulator(s)	____	____	____inches	____psig	____
4. Auxiliary Fuel Burners	____	____	____MBtu/hr		____
5. Stoker Grate	____	____	____Type		____
6. Boiler Fans ID	____	____	____Hp		____
Fans FD	____	____	____Hp		____
7. Boiler Economizer	____	____	____MBtu		____
Air Heater	____	____	____MBtu		____
Air Preheater	____	____	____MBtu		____
8. Isolation Dampers	____	____	____Sq. Ft	____Type(Butterfly)	____
9. Expansion Joints	____	____	____Sq. Ft		____
10. Sootblowers	____	____	____Ft	____Standard/Heavy	____
11. Drum Level Control	____	____	____		

NOTES:

Appendix G: Status Quo Program User's Manual

Introduction

The Status Quo database maintains an inventory of individual parts in a central heating plant (CHP) along with their installation years, costs (in a specified year), and lifespan. The database also keeps a record of the typical annual costs for operating and maintenance. This data is used to calculate the projected cost of operating the CHP in future years (i.e., maintaining its status quo). The Status Quo program displays a main menu that enables you to enter data about a particular base, to maintain files containing default costs and life expectancy of parts, to browse the raw data files, and to run prepared reports.

Installation

The Status Quo program is designed to run on an IBM PC or compatible computer with 640K of memory. The total hard drive space required is about 1.4 megabytes. For specific help with installation, see the README file on the installation disk. The programs are supplied on the disk in compressed form. Running the INSTALL program will create the necessary subdirectories on your hard disk drive and uncompress the programs. The programs are placed in two directories:

1. A user-supplied directory name that contains the Status Quo database files and programs. For example: C:\SQ. This directory may be renamed as desired.

2. A subdirectory of the above directory, named SQLCCID, that contains the LCCID (pronounced "el-cid") program for life cycle costing. This subdirectory must not be renamed, or the programs will not be able to move from one directory to another.

To install the programs, put the install disk in a floppy disk drive and select that drive. Then run the INSTALL program; for example:

A:	<Enter>
INSTALL	<Enter>

The program will prompt you to enter a drive and directory location for the files. It is not necessary to create the directory in advance because the program will do this if it does not exist. The program will also check for adequate disk space and adequate memory before starting the installation. As the program runs, it will uncompress the various files. When done, it will look for a CONFIG.SYS file on your C: drive. If the file does not exist, or if it does not contain the proper "Files=30" and "Buffers=30" statements, the program will display a message explaining what statements are necessary.

Starting the Program

Select the appropriate directory and type SQ, then press <Enter>. The first screen displays the MAIN MENU at the top. Menus feature a choice of actions to be performed. Actions may be selected by pressing <ENTER> when a menu item is selected or by clicking the left mouse button once. Use the arrow keys, page up and down keys, or the mouse to move through the menu selections. Use the <ESC> key to move back to the previous menu. On the first menu (the bar menu at the top of the screen), <ESC> will terminate the program. The diagram below shows the actions available from the MAIN MENU:

ADD DATA	DEFAULTS	BROWSE	REPORTS	TOOLS	EXIT
Enter base data	Enter or modify default data	View the raw data files	Summary SQLCCID	Set mod mode Add a new base Pack files Reindex files Browse Spool Escalate data	Quit

Adding or Modifying Records

The first time you attempt to enter the Modify Mode, you will be prompted to enter the password. (The default system password is in the README file on the Installation

Disk.) Modify Mode can also be turned on or off from the TOOLS MENU. In Modify Mode, the blinking cursor can be moved from field to field on the screen with the following keys: <ENTER>, <TAB>, <SHIFT-TAB>, <HOME>, and <END>. Other available keys are shown at the bottom of the screen:

<F1> Specific help for a data entry field. Placing the cursor on a field and pressing <F1> brings up a help screen for that field. (If no specific help has been defined for a field, general help will be displayed.) On some fields, pressing <F1> will pop up a menu of choices. Selecting an item and pressing <ENTER> will place the selected value in the field.

<F3> Used to save the newly entered or modified data. Any changes made on the screen will not be changed in the data file until this key is pressed. (Pressing <CTRL+END> simultaneously also saves the data.) When <F3> is pressed, the program checks for the validity of the entered data.

<F5> Clears field entries on the screen. May be used to clear out a number of entries when you discover that you have made an error.

<ESC> Exits the screen and returns to the previous screen without modifying the data. Use <ESC> to exit after making errors in data entry.

Automatic Data Validation in Modify Mode

Some fields have been programmed to accept only certain values. This ensures that keystroke errors or incorrect values will not be entered. If a field is programmed for this feature and you make an entry error, a beep will sound and a message box will appear in the upper right corner as soon as you attempt to move out of the field. You cannot exit the field until it is corrected. (You may, however, press <ESC> to break out of Modify Mode or <F1> for help.)

Browse Menu

This feature enables you to view the raw data in any file. This may be useful should a question arise as to whether the data exists or is in the proper form. This feature allows you to view the raw data, not to modify it.

Reports Menu

Selecting REPORTS on the top bar menu will pop-up a menu of currently available reports. Each report begins with a screen that describes the purpose of the report and asks you to fill in some information such as the name of the desired data. Follow the instructions on the screen to begin the report. Most reports will display on-screen messages as processing continues. (You may cancel a report in progress by pressing <ESC>.) When the report is complete, you will be prompted as to whether you wish to browse the results on the screen and/or print it. Output may be directed either to a dot matrix printer or to a laser printer with Postscript option. See **Running SQLCCID Reports** (p 98) for a discussion of how to run SQLCCID reports.

Tools Menu

This menu contains a number of utilities and useful features:

Add a Base - Used to add a set of files for a new base. See the descriptions of datafiles below.

Pack the Datafiles - As records are deleted from the files, open spaces occur, which may slow down the general performance. Packing the files reorganizes the data and deletes unused space. Packing will not harm the data and is rarely necessary.

Reindex the Datafiles - All the files have indexes, which keep the data in order. It is possible for an index to become damaged, in which case you may not be able to locate data. Reindexing rebuilds the indexes. It will not harm the data and is rarely necessary.

Browse Print Spool - Output from most reports is placed in a file named PRINT.SPL. You can view the output from the most recent report by selecting this option. This is useful if you have run a report and exited the REPORTS menu, but still want to review the output.

Escalate Data - The base cost figures used by Status Quo are in 1991 and 1992 dollars. This option escalates the base data to the year of the study being performed. You must input the base year to be escalated, the year to escalate to, and the escalation percentage.

Types of Data Files

1. Base CHP data files

There are four files for each database. Each filename begins with a basecode consisting of 1 to 4 characters an identifying word such as DATA or EXPL followed by a file extension such as DBF or IDX. The basecode is created from the Tools Menu when a new CHP is added. The basecode will usually be an abbreviation for the base name or the CHP name. In the following, the basecode is PIC for Picatinny Arsenal

PICDATA.DBF	-	the main datafile
PICDATA.IDX	-	the index for the main datafile
PICEXPL.DBF	-	the explanations datafile
PICEXPL.IDX	-	the index for the explanations datafile

2. System data files

These files contain default values such as the replacement cost of inventory items and life expectancy. They also contain code to check for validity of entries made with the ADD DATA program to ensure that you do not enter any values that are incorrect or out of the range of the default data.

DEFAULT.DBF	-	default data
DEFAULT.IDX	-	the index for the default datafile
VALID.DBf	-	validity checking data
VALID.IDX	-	the index for the valid datafile

Sample Screens

STATUS QUO DATA FILE - ADD MODE:

```
─────────────────────@ Enter Data for New Record: @──────────────────

   System      BOILER___

   Item        FTBOILER____

   Spec1
   000000.0    MBtu

   Cost of Replacement in Year 0000 Is $ 0000000
                 Default:  Year 0000 Is $ 0000000

   Year Installed  0000       Year of Replacement  0000

   Condition     _  (G-Good,F-Fair,P-Poor)

   For year of replacement other than expected, please explain:
   @──────────────────────────────────────────────────────────-@
   If cost of replacement differs from default, please explain:
   @──────────────────────────────────────────────────────────-@
        <F1>Help       <F3>Save       <F5>Clear Fields    <ESC>Cancel
```

DEFAULT FILE - ADD MODE:

```
─────────────────────-@STATQUO DATABASE: DEFAULT VALUES@──────────────
 System     |Item        |Spec1    |Spec2    |Spec3    |Cost     |Costyr|Lifespan|
@──────-@ @──────────-@ @──────-@ @──────-@ @───────-@ @──────-@ @──────-@ @──────

 BOILER     |FTBOILER    |    20.0|         |         | 600000|  1991|      25|
 BOILER     |FTBOILER    |    60.0|         |         |1100000|  1991|      25|
 BOILER     |FTBOILER    |   120.0|         |         |1700000|  1991|      25|
 BOILER     |FTBOILER    |   139.0|         |         |1390000|  1994|      25|
 BOILER     |FTBOILER    |   160.0|         |         |2000000|  1991|      25|
 BOILER     |FTBOILER    |   200.0|         |         |2300000|  1991|      25|
 BOILER     |RELVALVE    |     1.0|    600.0|         |    1900|  1991|      10|
 BOILER     |RELVALVE    |     1.5|    150.0|         |    1700|  1991|      10|
 BOILER     |RELVALVE    |     1.5|    300.0|         |    1800|  1991|      10|
 BOILER     |RELVALVE    |     1.5|    600.0|         |    2000|  1991|      10|
 BOILER     |RELVALVE    |     2.0|    150.0|         |    2400|  1991|      10|
 BOILER     |RELVALVE    |     2.0|    100.0|         |    1900|  1991|      10|
 BOILER     |RELVALVE    |     2.0|         |         |    2000|  1991|      10|
 BOILER     |RELVALVE    |     3.0|         |         |    2000|  1991|      10|
 BOILER     |WTBOILER    |    60.0|         |         |1100000|  1991|      40|
 BOILER     |WTBOILER    |   160.0|         |         |2000000|  1991|      40|
───────────────────────-@ Enter Data for New Record: @─────────────────

 BOILER     FTBOILER     000000.0 000000.0 000000.0 0000000   1991       25

                    <F1>Help        <F3>Save             <ESC>Cancel
```

Running SQLCCID Reports

This program is intended to help you determine the life cycle cost of an existing U.S. Army central heating plant. It runs the Life Cycle Cost in Design (LCCID) program to determine these costs based on input entered via prompt screens and data contained in the Status Quo database. LCCID is an economic analysis computer program furnished by the U.S. Government and developed by USACERL. LCCID may be run in three ways:

1. As a standalone program by selecting the SQLCCID subdirectory and typing LCCID <Enter>. Consult the separate LCCID User's Manual* for information about this usage.

2. From within Status Quo Database programs by selecting the option "Run SQLCCID" on the REPORTS MENU. Proceed with the first part of the program to create the necessary datafile, then select "Run LCCID Manually" from the pop-up menu that will appear after the study data is prepared. Consult the LCCID Users Manual.

3. From within the SQLCCID program, which produces a complete report automatically. Select "Run SQLCCID" from the REPORTS MENU. Proceed with the program to create the study datafile, and select "Life Cycle Report" from the pop-up menu. When the report is complete, you will be prompted to browse and/or print the output.

Before running this program, data must first be entered into the Status Quo database. This includes the annual maintenance expenses and all one-time-cost items for the 25-year period to be examined. These Status Quo datafiles do not need to be on the same directory as the SQLCCID programs. To add data to the Status Quo database, select "ADD DATA" from the Status Quo MAIN MENU.

Instructions For SQLCCID

1. To save the data entered on any screen, press or click <F3>. To cancel the program and exit from any screen, press or click <ESC>. From any screen in the program, you can view a help screen by pressing <F1>. (While the Status Quo

---

* L.K. Lawrie, *Development and Use of the Life Cycle Cost in Design Computer Program (LCCID)*, Technical Report (TR) E-85/07/ADA162522 (U.S. Army Construction Engineering Research Laboratories [USACERL], November 1985).

program is running LCCID, you may have to press <CTRL-BREAK> to terminate processing.)

2. The first screen asks for the studycode name and the name of the Status Quo database. Any name up to eight characters can be used as a studycode. The program will produce an input data file with the same name plus the extension ".LC," which contains the necessary data for LCCID to run. It will also produce a report with the studycode name and the extension ".RPT." If the studyfile already exists, the program will prompt you to reuse the existing file, or overwrite it with a new file.

```
                    STATUS QUO Life Cycle Costing

   Enter LCC Study Code:  TEST

   Enter name of STATUS QUO Database:  E:\SQ\SQDATA.DBF

                    File TEST.LC already exists

               @ Please select an option @
               | Use the existing file
               | Overwrite the file
               | Cancel this program
```

3. The Study Dates allows input of the essential dates for the study. The exact day is not critical for LCCID since all dates are assumed to be the first of the month. The program will check for the basic validity of the dates entered. Press <F3> to continue.

```
                          Study Dates

   Date of Study                               1 /01/91

   Midpoint of Construction                    0 /01/92

   Beneficial Date of Occupancy                0 /01/93

   Economic Life (Years)                       2

        <F1>Help             <F3>Save              <ESC>Cancel
```

4. The Study Identification screen inputs information that will appear at the beginning of the report. These items are optional except for location and fiscal

year. The location must be a valid state name or a valid two-letter abbreviation. The fiscal year must be entered as four digits, from 1990-2000. Press <F3> to continue.

Study Identification

Study location (state)	NEW JERSEY
Installation name	PICATINNY ARSENAL
Project number	WV9
Project title	CHP STATUS QUO
Design feature	A TEST PLANT
Name of study preparer	JOHN Q. SMITH
Fiscal year	1992

<F1>Help <F3>Save <ESC>Cancel

5. The Fuel Screen prompts for the cost of fuel and usage. At least one fuel and its corresponding usage must be entered. This screen completes the data entry. When you press <F3>, the program will beginning creating the .LC file using your answers and the data from the Status Quo database.

@ Fuel Costs and Annual Usage @

	COST	ANNUAL USAGE
Electricity	0.0000 $/MBtu	0 MBtu
Distillate Oil	0.0000 $/MBtu	0 MBtu
Residual Oil	3.0100 $/MBtu	928373 MBtu
Natural Gas	0.0000 $/MBtu	0 MBtu
Coal	0.0000 $/MBtu	0 MBtu
Propane	0.0000 $/MBtu	0 MBtu

<F1>Help <F3>Save <ESC>Cancel

6. A menu will appear allowing you to select the standard report, run LCCID manually, or cancel the program. For most purposes, you will select the Life Cycle Report option. The program will run automatically. When the report is finished, you will be prompted whether you wish to browse the report. Answer Y or N. (While browsing, you can also use the mouse to move from screen to screen.) The next prompt asks if you wish to print the report followed by a menu

of printer choices. (To use the laser printer, the file PS.EXE must be on the SQLCCID subdirectory or somewhere in the DOS path.)

```
@ Please select an option @
  Life Cycle Report
  Run LCCID Manually
  Cancel this program
```

You may be unable to print the report due to memory shortage. In this event, just exit the program normally. The report is now in the file <studycode>.RPT. It may be printed with one of the following commands:

Print on dot matrix printer on LPT1:

TYPE (studycode).RPT > LPT1 (Enter)

Print on laser printer on LPT3:

PS (studycode).RPT -s10 -dLPT3 (Enter)

In some instances you may want to run LCCID manually. This allows more adjustment and fine-tuning of the additional options available through manual operation. This program will already have created the input file. After beginning LCCID, select the option to use an existing file and enter the studycode name without the .LC extension. If memory problems occur, just exit from SQLCCID and run LCCID as a separate program by typing:

LCCID <Enter> - Run LCCID alone

USACERL DISTRIBUTION

Chief of Engineers
ATTN: CEHEC-IM-LH (2)
ATTN: CEHEC-IM-LP (2)
ATTN: CERD-L
ATTN: CECC-R

CECPW 22310-3862
ATTN: CECPW-FU-P

US Army Engr District
ATTN: Library (40)

US Army Engr Division
ATTN: Library (12)

US Army Europe
ATTN: AEAEN-EH 90014
ATTN: AEAEN-ODCS 09014

US Army Materiel Command (AMC)
Alexandria, VA 22333-0001
ATTN: AMCEN-F

FORSCOM
Forts Gillem & McPherson 30330
ATTN: FCEN

INSCOM
ATTN: IAV-DPW 22186

TRADOC
Fort Monroe 23651
ATTN: ATBO-G

HQ XVIII Airborne Corps 28307
ATTN: AFZA-DPW-EE

US Army Materials Tech Lab
ATTN: SLCMT-DPW 02172

USARPAC 96858
ATTN: DPW
ATTN: APEN-A

CEWES 39180
ATTN: Library

CECRL 03755
ATTN: Library

USA AMCOM
ATTN: Facilities Engr 21719
ATTN: AMSMC-EH 61299

Walter Reed Army Medical Ctr 20307

National Guard Bureau 20310
ATTN: NGB-ARI

Naval Facilities Engr Command
ATTN: Naval Facilities Engr Service Center 93043-4328

NAVFAC
ATTN: Code 1352 22332-2300

8th US Army Korea
ATTN: DPW (12)

USA Japan (USARJ)
ATTN: DPW-Okinawa 96376

USA TSARCOM 63120
ATTN: STSAS-F

American Public Works Assoc. 64104-1806

US Army HSC
Fort Sam Houston 78234
ATTN: HSLO-F
Fitzsimons Army Medical Ctr
ATTN: HSHG-DPW 80045

Tyndall AFB 32403
ATTN: HQAFCESA Program Ofc

US Army Envr Hygiene Agency
ATTN: HSHB-ME 21010

GMPA
ATTN: STRGP-FT 17070-5008

Defense Tech Info Center 22304
ATTN: DTIC-FAB (2)

99
3/95